



MARK CENTURY* NUMERICAL CONTROL

An advanced solid-state design for accurate, reliable control of continuous-path or point-to-point machine operations

* Trade-mark of General Electric Co.

GENERAL  ELECTRIC

...assuring success with numerical control



Numerical control is demonstrating its value in scores of applications. It can cut your manufacturing costs and increase productivity in countless ways. Maximum profitability, however, depends on the selection of a control system that provides the ultimate in performance, with a minimum of downtime and maintenance.

When it comes to selecting a system, you need to evaluate the control as thoroughly as you did the concept.

Whatever your criteria, General Electric invites you to study, evaluate and compare the Mark Century numerical control system.

Consider reliability. G-E design engineers have combined solid-state circuitry and modular construction in a sturdy, air-conditioned enclosure. These and other Mark Century design features are the result of more than a decade of General Electric experience in designing and building control systems and applying them on hundreds of different machines.

And performance. Application engineers analyze and coordinate Mark Century control and the most suitable servo drives with the machine you need. Maximum operating flexibility in set-up and production is afforded by more standard system features than any other control. There's a wide choice of optional features, too.

Simple and economical tape preparation, and simple, time-saving system test procedures add to control efficiency.

Service? General Electric's unmatched field engineering and service organizations are your assurance of proper installation and expert maintenance. And, a two-week Mark Century training school prepares your personnel to operate and maintain the control.

Examine the many Mark Century control system features described on the following pages. You'll recognize that you can depend on General Electric's Mark Century numerical control system for profitable production.

GENERAL  ELECTRIC

Mark Century Numerical Control

... adaptable to all metal-working machines

Positioning

Mark Century numerical positioning controls are designed for use on machines requiring automatic control of one linear or rotary motion, or up to five linear or rotary motions in combination. Controlled simultaneously or sequentially, each motion has its own separate servo drive for point-to-point positioning.

Binary-coded decimal data input is provided with one-inch-wide, 8-track perforated paper tape. The tape is prepared by a typist copying position coordinates from a manuscript with a standard punched-tape typewriter. All characters are in agreement with the Electronics Industry Association (EIA) standards.

Depending upon the machine's cycle time, positioning controls are equipped with readers that read at either 62.5 or 120 characters per second. The reader converts coded data to command signals, which, through servo drives and a precision feedback device, direct the machine tool to the proper position.

For optimum electro-mechanical matching of the control system output and the machine servo motors, General Electric offers a choice of servo drives. For the positioning system, silicon-controlled rectifier d-c motor drives are standard. Amplidyne-controlled d-c motors, hydraulic motors or pistons, or multi-speed clutch-type servos are also available.

Programming is based on an absolute positioning system wherein all position commands are related to a machine zero reference that can be varied by the operator, rather than in terms of departures from previous points.

Contouring

Mark Century contouring controls are capable of simultaneously controlling combinations of two to five linear, rotary, or tilt motions of a machine. Command data is introduced by a standard 1-inch, 8-track perforated tape prepared by a typist on a punched-tape typewriter.

The control's input tape reader may be mechanical, or photoelectric, depending on the reading rate required. Both readers are equipped with servo-driven reels for automatic rewinding.

Four different types of servo drives are available with Mark Century contouring control systems: Thymotrol® or silicon-controlled rectifier d-c motors, amplidyne-controlled d-c motors, or electro-hydraulic valve-controlled hydraulic motors or pistons. The machine application usually determines the type of servo drives applied.

Precise correspondence of command signal and machine position for each motion is continuously monitored by a feedback unit coupled directly to machine motion. The standard rotary resolver unit or optional Accupin* linear feedback device provide machine resolution of 0.0001-inch at 200 IPM.

With the Mark Century system, the contouring path is determined by function generators which operate with either linear or circular interpolation—according to program selection—to continuously produce exact simultaneous digital position commands for all controlled axes. The result is true precision contouring as contrasted with contouring by velocity vector control.

Typical applications

Positioning . . .

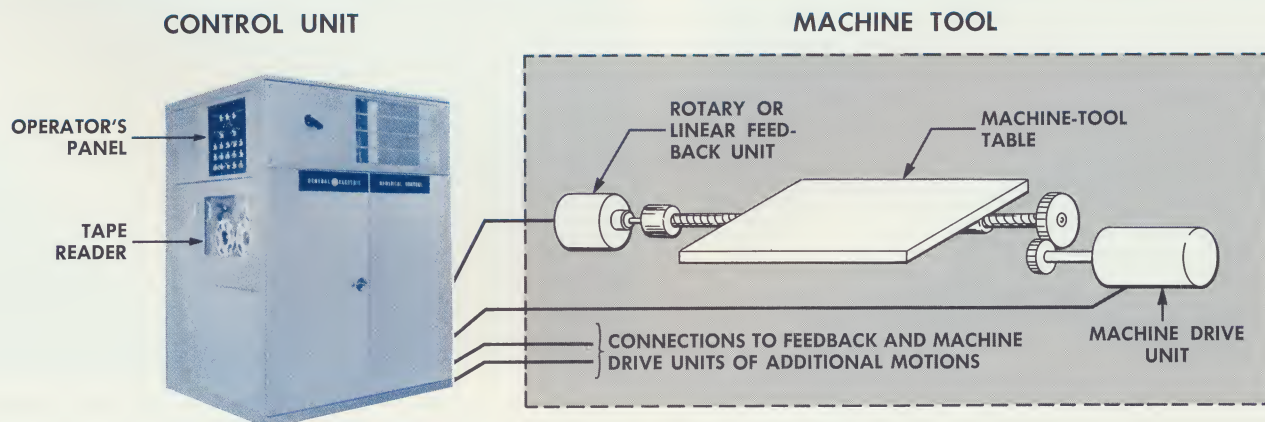
- Layout and Turret Drills
- Turret Punch Presses
- Horizontal Boring Mills
- Printed Circuit Board Drills
- Multi-purpose Drill-Mill-Boring Machines
- Allied Manufacturing Equipment:
 - Spot Welders
 - Pipe Benders

Contouring . . .

- Lathes
- Drafting Machines
- Profilers
- Die Sinking Machines
- Flame Cutters
- Skin Milling Machines

* Trade-mark of General Electric Co.

THE BASIC MARK CENTURY SYSTEM



Designed-in reliability . . . the result of General

Solid-state logic circuits

Mark Century numerical control systems take full advantage of the inherent reliability of properly designed transistorized, printed circuits, using them throughout the command generation portion of the control. Input data read from the tape is distributed, stored, and acted upon by 100-percent solid-state circuits. Modular printed-circuit boards are constructed of highest quality materials and components.

Modular construction

The logic-circuit portion of the control system is functionally arranged in modular-constructed, swing-out panels. Plug-in printed circuit boards clearly identified by type, and plug-in receptacles pin-coded to accept only the proper type of module board, make board changing easy and foolproof.

Advanced wire-wrap methods

Increased reliability in the command generation portion of the Mark Century control system is afforded by the use of advanced wire-wrap techniques on all terminal connections. Each solderless connection—as many as 20,000 in the multi-axis control systems—is tested with automatic test equipment to assure proper wiring and positive contact.

Programmed automatic circuit tester

Detecting improper wiring or faulty connections that may manifest themselves only after the control system is put into actual operation is accomplished in the factory by a General Electric-designed automatic circuit tester. Operated from a punched tape programmed from a wiring table, it scans thousands of terminal connections one by one for continuity and extra wires.

If the tester detects faulty wiring, a projection-type readout display provides the circuit point number, tape block number, and whether it is a missing or extra wire. This information is recorded for subsequent correction.

Control of machine magnetics

Mark Century control systems are furnished with complete machine magnetics when requested. All controls include a steel bulkhead and isolation circuits between the logic circuits and power initiation devices. This construction permits the inclusion of starters and other power devices within the main control enclosure. System design and installation is simplified by this unified approach.

Sturdy, air-conditioned control design

By taking advantage of the lower volume requirements of solid-state cir-

cuitry and modular construction, the basic Mark Century control system has been designed into a compact, floor-mounted, console-type unit. The control is equipped with an air-conditioning unit for positive control of the temperature and humidity of the air recirculating within the enclosure. This closed cooling system helps eliminate contamination from dirty and humid shop air, and assures optimum performance.

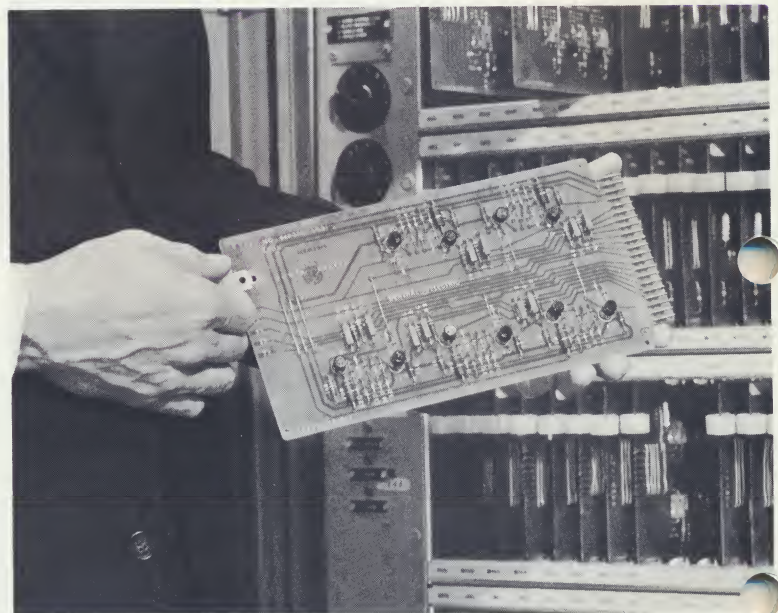
The interior of the control enclosure is divided into separate compartments; one for the logic circuits, and another housing machine-control power supply and related equipment. Interior panels are mounted on swing-out frames, affording easy access for maintenance.

The system is designed to meet all applicable requirements of the National Machine Tool Builders (NMTBA) machine tool electrical standards. To simplify installation, most connections to machine-mounted elements are made by plugs and receptacles inside the control enclosure with cables brought out through strain relief bushings.

Operator convenience is highlighted throughout the console design. Industrial, miniature, oiltight pushbuttons and selector switches are functionally arranged on the control panel. Indicating lights are provided for all self-check circuits.

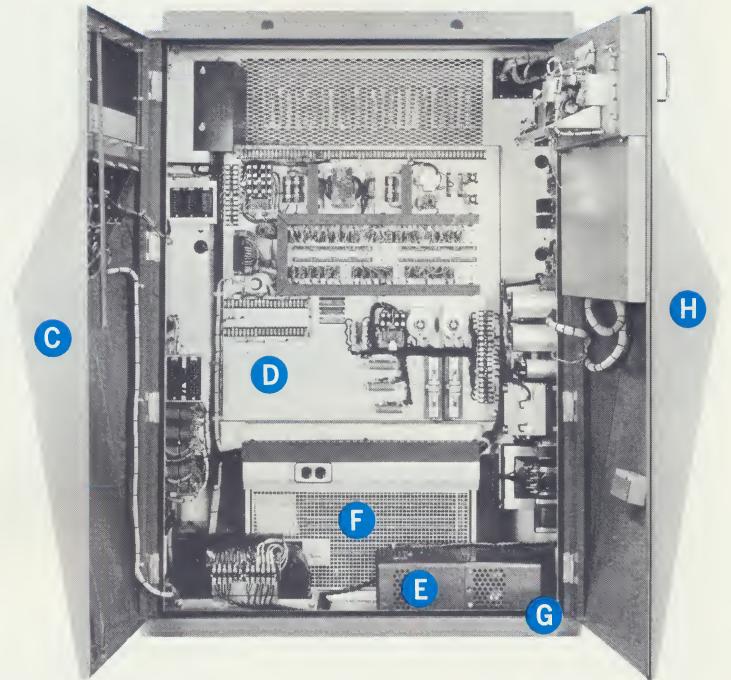


"Ringing out" control system circuits is done with a programmed Automatic Circuit Tester. Operated by punched paper tape, it provides a visual display of faulty wiring.



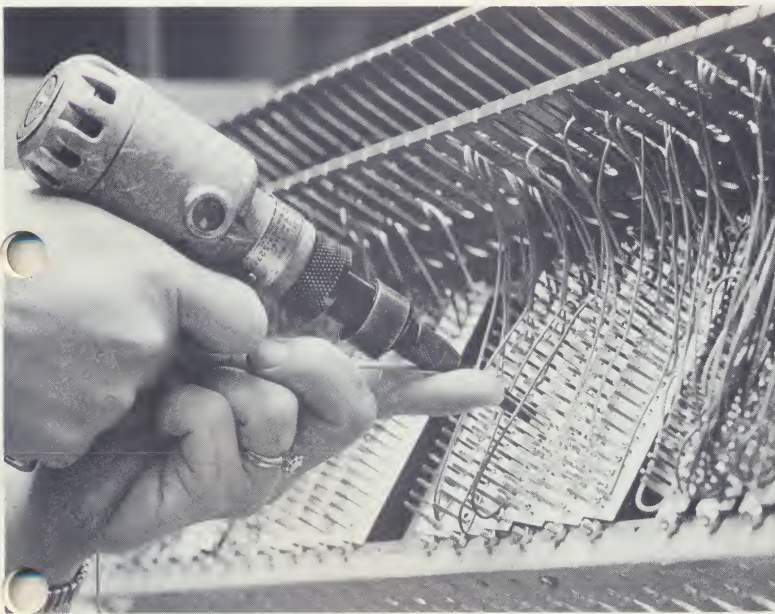
Solid-state circuit boards of highest quality materials and components contribute to Mark Century reliability. Modular boards slide easily into coded racks.

Electric's unmatched experience in machine-tool control



Front view of positioning control cubicle

- A** Operator's controls are conveniently mounted on sloped panel
- B** Tape reader is conveniently mounted near operator's control panel
- C** Full-width, swing-out doors provide access to all control elements
- D** Steel bulkhead and isolation circuits protect logic circuits from machine- or shop-generated electrical noise
- E** Constant-voltage transformer compensates for line variations
- F** Air conditioner controls temperature and humidity
- G** Fully gasketed doors seal unit from dust and fumes
- H** Controls are housed in heavy-gage steel enclosure



Advanced wire-wrap techniques are used for all logic-circuit terminal connections. Each connection is tested for proper wiring and positive contact with an automatic circuit tester.



Printed logic circuit boards are functionally arranged in sturdy, modular-constructed swing-out frames to facilitate control inspection and maintenance. Each module board is identified by number on rack sections.

You get more standard features with Mark

Contouring . . . standard features

Mark Century contouring controls include as standard the most advanced concepts in contouring techniques.

Binary-coded decimal format for tape input simplifies programming and permits a wider choice of optional programmed functions. Maintaining tape commands in BCD form throughout the control eliminates the conversion steps required with controls using other numbering systems.

The standard contouring control system also includes a manual-data-input panel that enables the operator to perform from the console any operation that can be performed by tape. This feature is invaluable for set-up and prototype work.

All Mark Century contouring controls include computing circuits that automatically generate clockwise or counter-clockwise arcs from end-point and center-offset information. The programmer can select either linear or circular interpolation for minimum tape length.

Other standard Mark Century contouring control features include:

Feed-rate over-ride capability from 0 to 120 percent of programmed value. The operator can speed up or slow down programmed feed rate at will to compensate for varying hardness, change of material, etc.

Feed-hold function allows the operator to stop the control at any time without losing synchronization. The machine resumes its programmed path as soon as the button is released.

Data input to four decimal places.
Servo drives—A choice of servo drives

is available with Mark Century control: silicon-controlled rectifier d-c motors, amplidyne-controlled d-c motors, or hydraulic motors or pistons. Control feedback from positioning and velocity loop increases system stability. Drives can go from stop to traverse speed in one step without losing synchronism.

Automatic operational test circuits—See page 8.

Full-range, zero offset—An incremental feed selector switch is mounted on the operator's panel, allowing the operator to move machine slides rapidly and under servo control for selected precise increments.

Machine mode selector—All Mark Century controls can be operated in three modes:

Automatic—All machine commands come from programmed tape.

Semi-automatic—Machine operates from commands entered by operator on manual-data-input panel.

Manual—Right-Left jog buttons permit servo operation of each machine axis under manual control.

Zero-position pushbutton—This initial-position control eliminates the need for expensive position readout equipment. Depressing the button sets all control counters to zero dimension and causes the controlled motions to operate at traverse speed until their respective zero limit switches are actuated. At this point the machine is synchronized and ready to start a contouring cycle.

Tape parity check—Reading error or parity check of each character read from



the tape is provided. A tape error will stop all motions at the last command and illuminate a "reading error" light.

Out-of-synchronism protection—Automatic servo error circuit stops all machine motions, and illuminates "out of synch" light when the differences between commanded and actual positions exceeds a predetermined amount.

Mirror-image control cuts programming time for symmetrical parts from $\frac{1}{2}$ to $\frac{1}{4}$ of original time.

Miscellaneous functions—A block of ten auxiliary functions—such as on-off circuits, coolant flow and clutch circuits—that can be programmed on the tape is included with each Mark Century Control.

Rotary resolver feedback unit provides precise correspondence of command signal and machine member to resolution of 0.0001" at cutting speed of 200 IPM, 0.00001" at 20 IPM.

. . . optional features

Tape readers—Standard tape reader is a 62.5 characters per second mechanical or a 120 characters per second photoelectric, depending on the type of control. A photo reader that reads at 300 and another that reads at 500 characters per second are available as an option.

Tool-zero offsets provide the operator with a precise method of setting the cutting edge of a boring or turning tool. Digital offsets are provided for each tool in a turret in two axes of machine motion, ± 0.0999 ".

Thread cutting—Gearless thread cutting and drum scoring is provided by this Mark Century option. Right-hand or

left-hand threads, tapered threads or variable-pitch threads can be cut with the appropriate tape command.

Position indication provides readout of the position for each machine slide as commanded by the control system from the time the indicator was set. This option provides a six-digit display with plus or minus signs which indicate position for motions in either direction up to 99.9999".

Sequence number readout—This display indicates to the operator at all times the sequence that the machine is carrying out. It also gives him the ability to search out and repeat any particular machine sequence.

Block dimension multiplier increases maximum programmable departures from 9.9999" to 99.9999", thereby simplifying program and reducing tape length on large machines. Permits cuts up to 99 inches in a single block without loss of accuracy.

Accupin linear feedback device—This induction-type linear feedback unit eliminates lead-screw errors, and the effect of machine wear on accuracy.

Tool selection—This option provides the logic for automatic selection of tools.

Spindle speed selection provides the logic for automatic selections of spindle speeds.

Century, plus a wide choice of options

Positioning

... standard features

A truly absolute measure of tool position is provided with the standard Mark Century positioning system. Programming of data is based on a machine-zero reference point that can be varied by the operator over the full range of machine travel with **manual-data-input** zero-offset selector switches. The position coordinate as read from the tape is added to the zero-offset on the dials to give the position command. Six-digit switches are provided for each motion so that the offset can be resolved to 0.0001 inch.

These zero-offset selector switches can be used in the **semi-automatic mode** of control to command a position without tape data input. In this mode, when the "cycle start" button is depressed, the zero-offset data is read in as the only command, and the machine moves to those coordinates. This means of positioning is useful in servicing and in initial set-up.

The Mark Century positioning control is programmable to 0.0001" with binary-coded decimal tape input. The standard control accepts a six-digit input (98.0000"). A seven-digit input system is available for larger machines (998.0000").

Other standard positioning control system features include:

Rotary resolver feedback unit provides correspondence of command signal and machine tool position to 0.0001" at maximum cutting rate of 200 IPM; 0.00001" at 20 IPM.

Servo drives—For positioning motors rated at 1 hp or less, a silicon-con-



Typical positioning control panel

- 1 Projection-type sequence number readout keeps operator posted on progress of machine cycle (optional).
- 2 In-position light indicates true position prior to initiation of automatic spindle feed (standard).
- 3 Reading-error light indicates error in reading of tape input. Control operation is automatically stopped (standard).
- 4 Cycle start and stop buttons initiate tape cycle, and stop tape cycle at any block (standard).
- 5 Zero-offset thumbwheel dials provide full-range offset of machine zero. May be used for manual programming of x and y coordinates (standard).
- 6 Spindle selection switch for use in set-up or manual programs (optional).
- 7 Drill-mill selector and speed control provides straight-line, adjustable-speed milling (optional).
- 8 Jog buttons provide manual control of machine motions (standard).
- 9 Position-stop button permits operator to interrupt machine cycle at any time (standard).

trolled rectifier drive is generally used with a d-c motor. This drive has the advantage of simplicity, small size and high reliability. For applications requiring motors of more than 1 hp, amplidyne drives, hydraulic motors or pistons, or control for multi-speed

clutch operation with a-c motors are offered as options.

Auxiliary machine functions—A standard provision is a block of ten auxiliary functions—such as program stop and coolant control—that can be programmed in the tape.

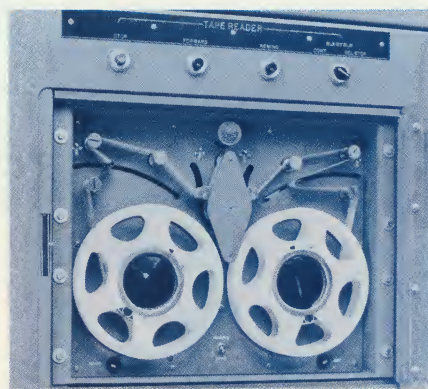
... optional features

Accupin linear feedback unit provides machine resolution of 0.0001".

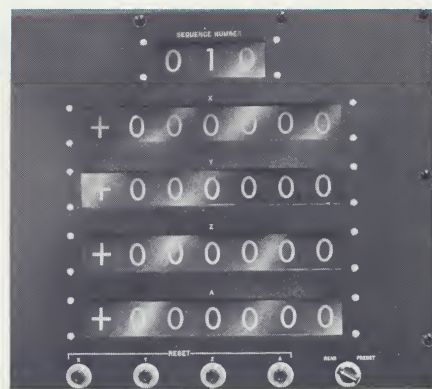
Tape readers—Standard tape readers read at 62.5 characters per second or 120 characters per second. If required, 300 or 500 characters per second photoelectric readers are available as an option.

Position readout provides digital display of actual machine position. This option enables the operator to monitor those operations involving machining of costly parts to guard against program error.

Sequence number readout provides operator with digital display of tape sequence the machine is carrying out.



Photoelectric tape readers capable of reading at a rate of 500 characters per second are available with Mark Century controls.



Position readout, available with General Electric contouring or positioning controls, provides digital display of machine-tool position.

Specify Mark Century, and benefit

Automatic test provisions . . .

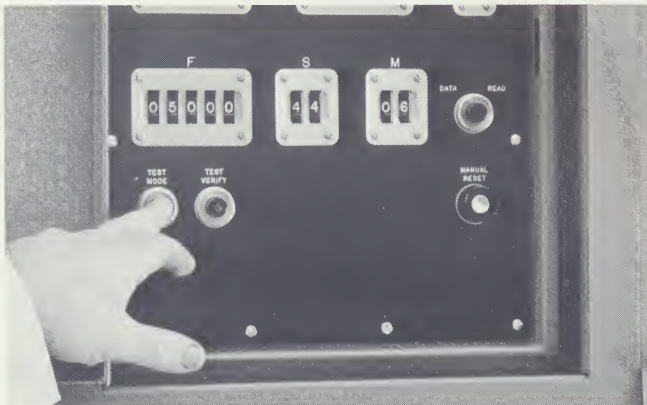
A systematic method of detecting, locating and correcting system malfunctions is accomplished by means of check-tape-controlled circuitry built into the Mark Century contouring control.

A master check tape provides the operator a quick, simple means of periodically testing system operation. In a typical system, depressing a test-mode button located on the control panel initiates check-tape-controlled operation and lights a "test-verify" lamp.

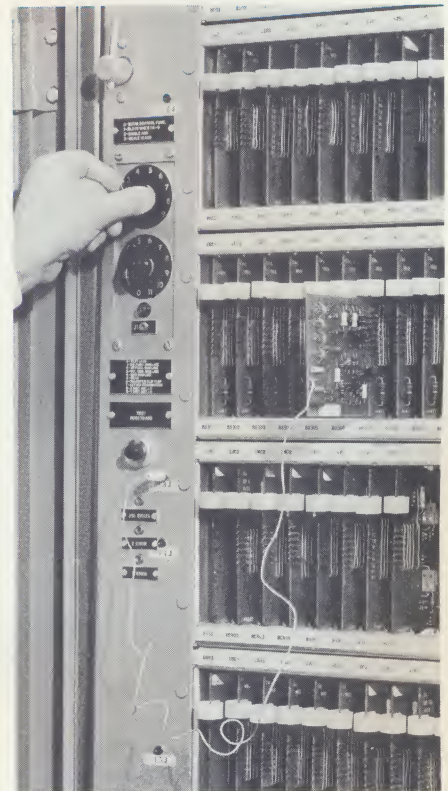
Improper operation is indicated if

the lamp goes out. A complete check of the system with the check tape can be accomplished in one to five minutes.

Locating and correcting control malfunctions is normally done by maintenance personnel, using supplemental test tapes. Built-in test switches and plug-in condition-indicator boards supplied with the control can be used to determine the exact location of the fault. The automatic test-verify circuit is capable of detecting errors of as little as 1 increment in 100,000.



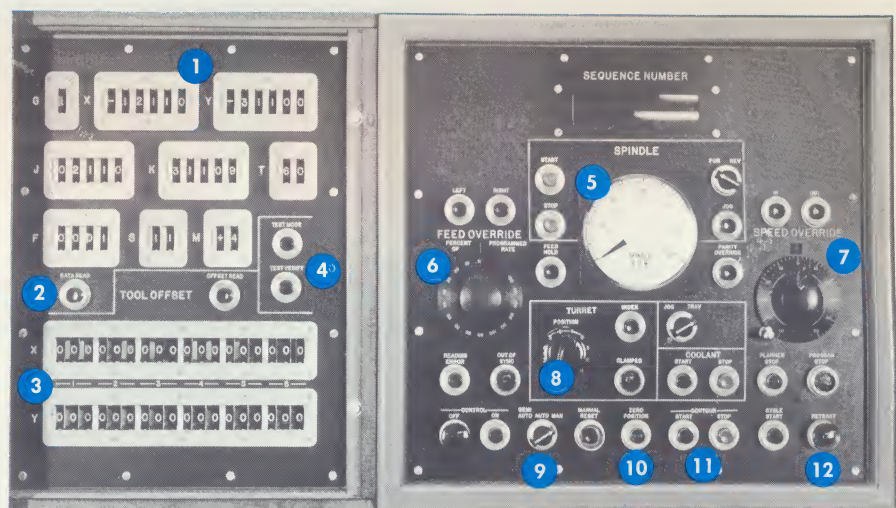
Test-mode button actuates tape-controlled circuitry for rapid check of control performance. Faulty operation is indicated if test-verify lamp goes out. Control can be completely checked out in one to five minutes.



Built-in circuitry and plug-in condition indicators provide a ready-made means of locating a defective logic-circuit board.

Operating flexibility . . .

- 1 Manual-data-input panel for semi-automatic operation
- 2 Data read-in button
- 3 Tool-offset adjustment
- 4 Automatic test-verify
- 5 Manual spindle control panel
- 6 Feed-rate over-ride
- 7 Speed over-ride
- 8 Manual turret control



Typical 2-motion contouring control panel

- 9 Semi-auto, Auto, and Manual mode selector switch
- 10 Zero-position control
- 11 Contour start and stop buttons
- 12 Tool retract button

from these important system features

Accurate, reliable performance . . .

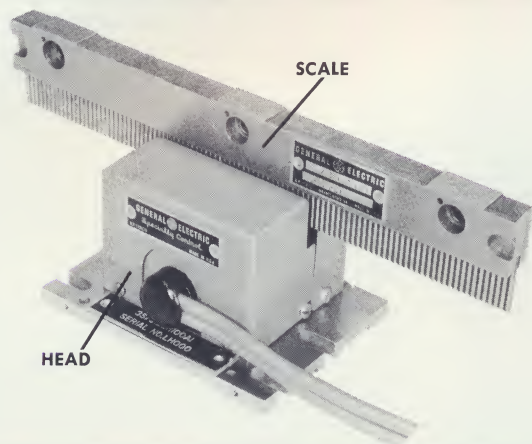
Factors contributing to accuracy in positioning or contouring must include the properly coordinated machine-control combination. G-E application engineers work closely with machine tool builders, analyzing and coordinating Mark Century control and servo drives with the machine. The result is a machine control combination pre-engineered for ac-

curate, reliable production.

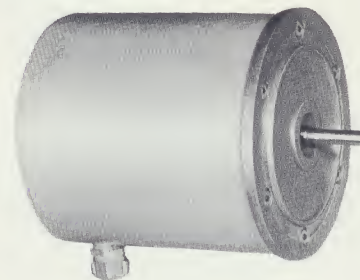
Precise correspondence of machine-tool position and control command signal is accomplished by means of a rotary resolver coupled directly to machine motion. Each motion has its own servo drive and feed-back loop. The standard rotary resolver and gearing provides servo resolution of 0.0001"

at cutting rates up to 200 IPM, or 0.00001" at 20 IPM.

The highly accurate Accupin linear or rotary feedback device is optional with Mark Century control. It permits operation without the use of a lead screw, providing 0.0001" resolution or 0.000001" per revolution.



High-accuracy Accupin linear feedback device is optional with Mark Century numerical controls.



Rotary resolver, used as standard feedback method, is coupled directly to machine motion.

Simplified programming . . .

Contouring

Data input to the Mark Century system has been carefully selected to make manual programming possible with simple two-motion contouring, and still make computer-assisted programming adaptable where facilities are available.

Programming continuous-path control of simple slopes and arcs of circles can be done manually or with a desk calculator. Circular and linear interpolation, standard features on Mark Century, make all the computations needed to produce curved surfaces.

It is necessary to program into the tape only that information which usually appears on the drawing, plus basic auxiliary function commands. For straight-line movements and slopes, only end-point coordinates and path velocity are needed. For arcs, end-point coordinates, arc-center offsets and feed rate are programmed. With this data, a typist prepares a tape which serves directly as the control program input.

For contouring in which curved paths are generated as a series of closely spaced slopes, computer-assisted programming may be the most economical approach. Post-process computer routines for use with the APT (Automatically Programmed Tools) System are available to APT members.

Positioning

The absolute coordinate system used with Mark Century positioning controls offers several advantages over the incremental system of programming. Commands are from a zero reference rather than in terms of departures from previous points. Thus, you don't need to work with plus and minus numbers, you don't need to resynchronize each

time power is turned on or a new program started, and you get maximum flexibility in planning the tool path.

Mark Century's variable block word-address format permits variable command length. Since there is no need to repeat information to fill a block of data, programming time is substantially reduced.



Copying from a manuscript containing position coordinates, feed-rate speeds, dimensions, and other necessary program data, a typist prepares punched-paper tape for either positioning or contouring controls with a standard punched-tape typewriter.

Two-week factory training school available to Mark Century users

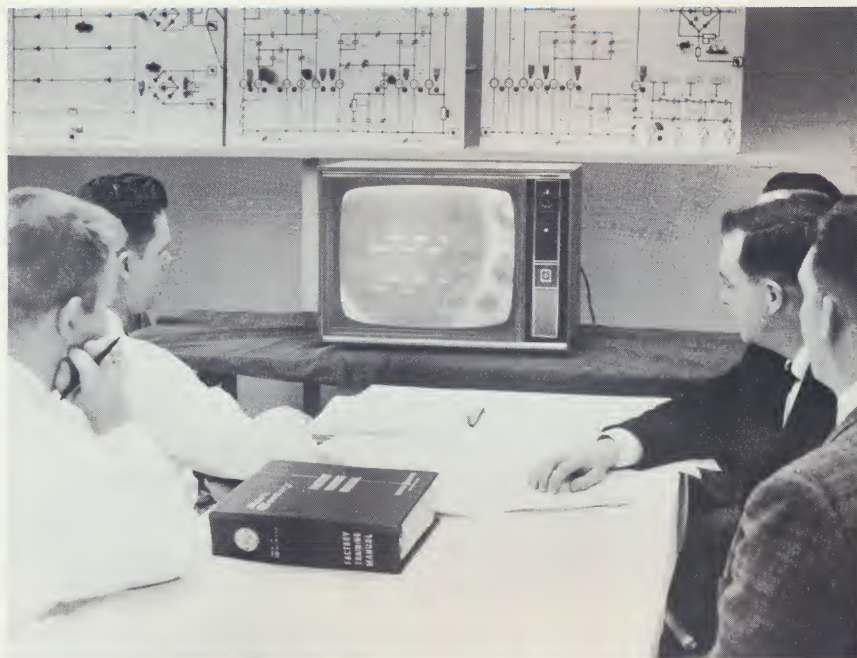
For effective servicing, maintenance personnel should know what the system is supposed to do, and understand the operating principles. This is exactly why General Electric provides a two-week training school for Mark Century users.

The first week is devoted to theory on digital, solid-state electronics. Discussion of basic static-logic fundamentals is followed by the subject of binary numbers and their association with static-logic circuits. In later sessions, the students have the opportunity to connect printed-circuit-board components, and observe their inputs and outputs.

In the second week, students work with actual equipment for familiarization with system operation, automatic test and maintenance procedures, and servo system performance.

The school provides complete classroom facilities including closed-circuit television, visual aids and trainers. The instructors selected to teach particular phases of the control system are expert in their fields.

Actual oscilloscope display from test set-up is brought to students with closed-circuit television.



Trainer sets provide practical experience in operating control system elements for better understanding of system functions.



First week is devoted to system fundamentals, second week to operation and maintenance. Class size ranges from 20 to 25 students.

General Electric engineering services assure you of successful installation and maintenance

When you specify Mark Century numerical control, you take advantage of industry's biggest "added value"—General Electric's unmatched field engineering and service organizations.

If the machine you need isn't already pre-matched with Mark Century control, the matching begins the instant your specifications are known. G-E

application engineers—who work closely with every major machine tool builder—help to translate your needs into an integrated machine-control combination that is completely checked out before it comes to you.

When your machine-control equipment arrives, G-E installation specialists are on hand to assist with installa-

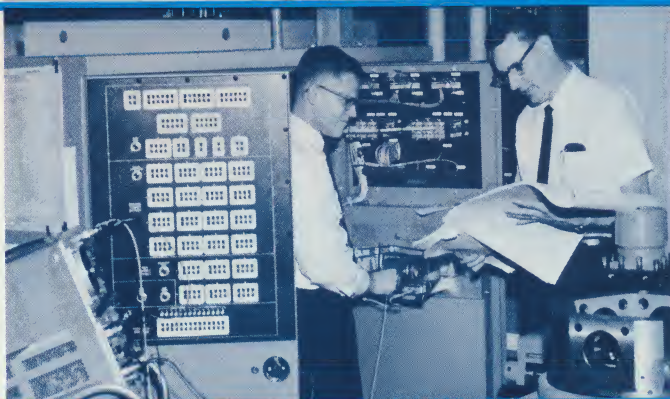
tion and start up to see that it performs to specifications. And when you need fast, skilled maintenance service, an engineer from one of General Electric's 90 strategically located offices can provide it.

When you insist on General Electric Mark Century numerical control, you assure yourself of profit-making machine tool performance—and then some.

Expert application help is available from engineers who have applied G-E control systems to over 50 types of machines.



Installation specialists assist in the start-up of every machine-tool application of General Electric numerical control.



Service engineers located in 90 principal cities across the country are on call for fast, skilled service when you need it.

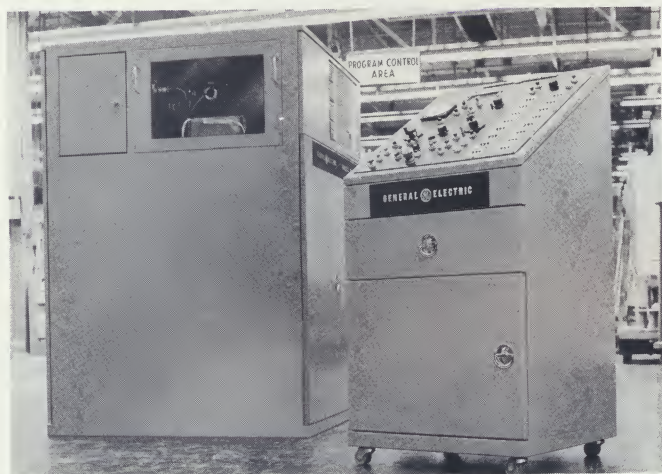


Standard or custom designs for every application

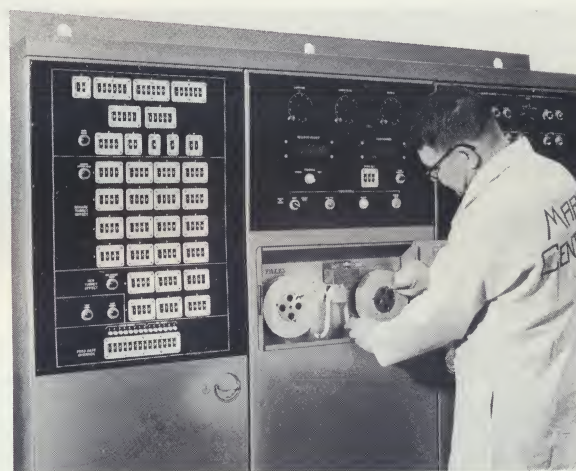
General Electric control systems are presently operating on more than 600 installations, on machine tools built by over 50 different manufacturers. Industry-wide acceptance of G-E numerical control systems stems from outstanding performance—performance that is being demonstrated daily in every major metalworking industry. No matter what your performance requirements may be, there is a Mark Century numerical control system to fit your needs. Contact your G-E Sales Engineer or machine-tool distributor today for application assistance, or more information about Mark Century numerical control.



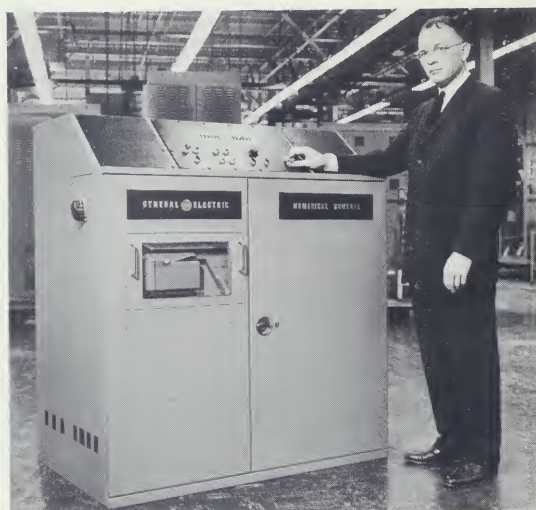
4-motion combination positioning and contouring control systems



2-motion contouring control with mobile console



3-motion contouring control



2-motion positioning control

Progress Is Our Most Important Product
GENERAL  ELECTRIC

SPECIALTY CONTROL DEPARTMENT, WAYNESBORO, VA.



Mark Century* 100B Numerical Positioning Control

A packaged Mark Century two- or three-axis system
for automatic operation of horizontal boring mills

*Trademark of General Electric Company

GENERAL  ELECTRIC



Mark Century 100B

numerical positioning control

easily justified in any plant...

Mark Century packaged numerical controls are available in several models—each tailored to a special type or group of machines. The 100B control is designed particularly for use with horizontal boring mills and there are other G-E packaged systems for machines with different control requirements such as drilling, turning, and milling.

All G-E packaged controls come in a basic design with a number of pre-engineered options which can be added inexpensively for extra versatility. The user benefits from the packaged design concept by getting a high performance N/C system on machines of his choice without paying for unnecessary features.

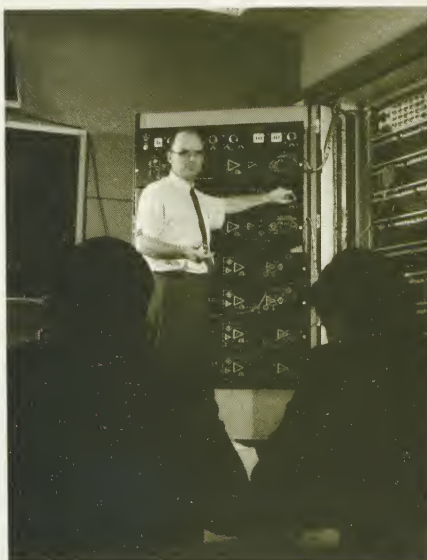
Furthermore, all G-E packaged controls are substantially similar in design and construction and this compatibility can reduce operating costs significantly where several are in use. Training expenses are less and overall operating efficiency is improved as a result of similarities in programming and maintenance.

The 100B control is offered by the leading builders of horizontal boring mills. For the user, these machines with the Mark Century 100B control offer outstanding value.

Highly reliable

The Mark Century 100B control employs the same high quality construction standards and components found in all General Electric Mark Century controls. Furthermore, reliability of the 100B control is backed by General Electric's more than a decade of experience in building numerical controls for over 100 different machine-tool manufacturers.

G-E Mark Century 100B numerical control systems take full advantage of the inherent reliability of transistorized, printed circuits. Input data is distributed, stored, and acted upon by solid-state circuitry.



Factory training schools for your maintenance personnel.

Total service package

When the Mark Century 100B control is delivered to your plant, G-E installation startup and check-out specialists are on hand to assist with installation and to make certain the control operates according to specifications. And should you need fast, skilled maintenance service, General Electric N/C Service Engineers from a network of over 50 offices can provide it.

But our service doesn't stop there. G.E. offers the most complete service package in the industry today. For example, these services are available to every Mark Century numerical control customer:

- Training schools for your maintenance personnel
- Automatic check tape for decoding circuits
- Unmatched product warranties
- Local stocks of replacement parts
- Complete service and installation manuals
- Printed circuit board exchange plan
- Computer software support
- World-wide maintenance service



Optional photoelectric tape reader makes system completely automatic.

for 2- or 3-axis boring mills

The Mark Century 100B control is a 2-axis N/C system suitable for both positioning and straight line milling at manually set feed rates. Optionally, it can be expanded into a 3-axis system for head, table, and saddle control of a horizontal boring mill.

Maximum flexibility

The basic Mark Century 100B control operates entirely from manual inputs. A photoelectric tape reader can be added optionally to make it a completely automatic system.

Manual input devices on the operator's panel allow complete machine control including plus or minus departure commands and full floating zero position selection. Manual input capability also includes a choice of ten preparatory commands for selection of automatic machining modes, and anyone of 99 miscellaneous commands as assigned by the machine tool builder.



Manual data input panel takes preparatory, miscellaneous, and individual axis commands.

The 100B control has a 4-speed clutch servo drive for each motion. This servo drive coupled with the preparatory command function provides a unique flexibility to the operator. Typical modes of operation include:

- Selectable by "G" commands
- Coarse positioning
- Fine positioning
- Selectable backlash takeup
- Anticipation milling to avoid overshoot on inside corners
- Drilling, boring, or tapping cycles

What's more, all 4-speed zones are adjustable. This allows the control to be matched to machines covering a wide range of sizes and operating speeds.

Other optional features include sequence number readout, rotary or linear Accupin* feed-back units, and initial position circuits for rapidly returning to an absolute reference on the machine.

Operator convenience and easy maintenance

The console is designed for maximum operator handling ease. Operator's devices such as the latest miniaturized push buttons are functionally arranged on a sloping panel across the top front of the unit.

A check tape and condition indicator boards provide fast, thorough checkout of the control reading and data storage circuits.

The logic-circuit portion of the control system is functionally arranged in modularly constructed panels. Plug-in printed circuit boards—clearly identified by type and plug-in receptacle number—make board changing easy and foolproof.

A modern NEMA 1, pressure-ventilated, floor-mounted enclosure houses all control components. Machine control connections are made with plug-in connectors, and swing-open gasketed doors front, back, and top provide easy access to all parts of the unit. Interior walls are painted white for maximum visibility.

And the Mark Century 100B positioning control is compact. It measures only 44-inches wide, 28-inches deep, and 54-inches high.

*Trademark of General Electric Co.

Mark Century 100B

numerical positioning control

Standard Features

Table Motion (X-axis)—7 digit programmable to ± 999.9999 inches.

Head Motion (Y-axis)—6 digit programmable to ± 99.9999 inches.

Full Floating Zero—Simplifies set up of large work pieces. Zero may be set on or off the table as desired.

Plus or Minus Programming—Axis commands can be programmed either side of the zero reference.

Resolution—Control accepts data to .0001 inch; makes possible full utilization of accuracy built into the machine tool.

Four-speed Clutch-type Servo Drive—Gives complete flexibility of machining modes.

Adjustable Servo Speed Zones—Provides optimum performance for machines with wide range of operating speeds and dynamic characteristics.

Automatic Machining Modes—Preparatory commands simplify programming by establishing automatic machining sequence.

Manual* Data Input Panel—Accepts preparatory (G-function) and miscellaneous (M functions) as well as individual axis commands.

Manual Operation—Plus-minus jog buttons permit servo operation of each machine axis under manual control.

Feed Hold Button—Permits operator to interrupt motion at any time without loss of position.

Accupin Linear Transducer—Provides direct measurement of machine position. Adjustment and wear problems are eliminated.

99 Miscellaneous Functions—Provides opportunity for full range of programmed machine functions. Typical functions include tool selection and coolant control.

Optional Features

Spindle or Saddle Motion (Z) Axis—6 digit programmable to ± 99.9999 inches.

Initial Position—Provides an automatic rapid traverse circuit for each axis to an absolute zero reference position on the machine. The initial position and direction of zero travel may be established by the machine builder.

Photoelectric Tape Reader—This plug-in option may be added at the factory or in your shop. The kit includes reader, amplifier and cables. This feature also includes parity check, parity override and sprocket hole verification.

Sequence Number Readout—Provides a 2 digit projection-type, numerical readout of tape sequence number.

There is a Mark Century numerical control system to fit your needs no matter what your performance requirements may be. See your G-E Sales Engineer or machine-tool builder's representative for more information about the Mark Century 100B and other General Electric numerical control systems.

Specialty Control Department, Waynesboro, Virginia.



GENERAL  ELECTRIC



MARK CENTURY* 100S Numerical Contouring Control

A packaged 2-motion numerical contouring control
for turning and profile milling machines

* Trademark of General Electric Co.

GENERAL  ELECTRIC



MARK CENTURY 100S

numerical contouring control

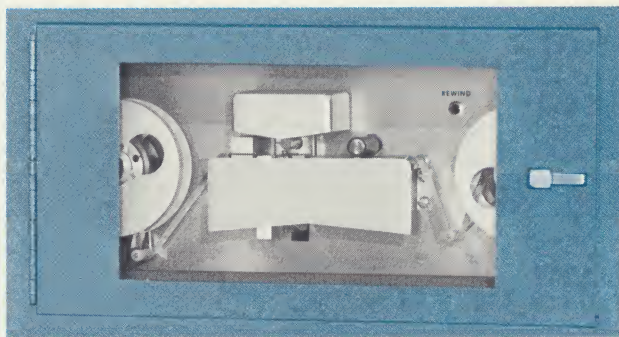
easily justified in any plant...

Mark Century packaged numerical controls are available in several models—each tailored to a special type or group of machines. The 100S control is a two-axis contouring system for turning and profile milling machines, and there are other G-E packaged systems for machines with different control requirements such as point-to-point operations, boring and milling.

All G-E packaged controls come in a basic design with a number of pre-engineered options which can be added inexpensively for extra versatility. The user benefits from the packaged design concept by getting a high-performance N/C system on machines of his choice without paying for unnecessary features.

Furthermore, all G-E packaged controls are substantially similar in design and construction, and this compatibility can reduce operating costs significantly where several are in use. Training expenses are less, and overall operating efficiency is improved as a result of similarities in programming and maintenance.

Since its introduction, the Mark Century 100S numerical control has received wide acceptance and is offered by a great many machine builders. The latest model of the 100S control, described here, incorporates a number of new features and improvements for added value to the user.



Standard photoelectric tape reader provides high speed data input at 300 characters per second.

Highly reliable

With the Mark Century 100S control, you receive the same high quality construction found in all General Electric N/C systems. Mark Century control design is the result of more than a decade of G-E experience in designing and building control systems and applying them on thousands of different machines for over 100 machine-tool manufacturers.

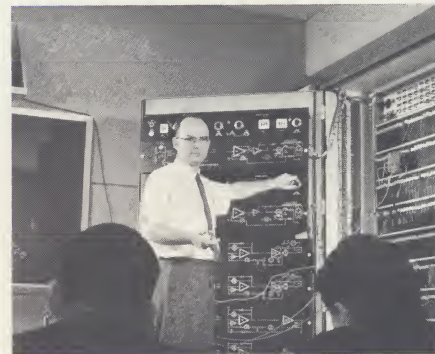
A single cabinet houses all control components to make the Mark Century 100S control compact and easy to service. The operator's console utilizes the latest in miniaturized push buttons for operator ease and fast, reliable operation. Command input is from EIA-standard, 8-channel punched tape. Printed circuit boards and components are interchangeable with other G-E controls.

Because the 100S control is carefully matched to each builder's machine, installation and start-up at your plant is quick and easy.

Complete service

A special Mark Century 100S control maintenance training school is available from General Electric for your personnel. And this is just the beginning, for G-E offers the most complete service package in the industry today. Other services include:

- Automatic check tape for logic circuits
- Unmatched product warranties
- Local stocks of replacement parts
- Complete service and instruction manuals
- Printed circuit board exchange program
- Computer software support
- Local service engineers on call 24 hours a day for world-wide maintenance service



G.E. training school educates your maintenance personnel in the care of your Mark Century 100S control.

Mark Century 100S

numerical contouring control



Standard Features

High-speed Reader—A high-speed, 300-characters per-second photoelectric tape reader is provided.

Full Circular Interpolation—Permits programming arcs up to 90 degrees with a single block of input data.

Miscellaneous Functions—Increase versatility. A block of 100 auxiliary functions—such as on-off circuits, coolant flow and clutch circuits—can be programmed on the tape. Other circuits can be assigned to control spindle speeds and gear changing, to provide more automatic control of the machining process.

Spindle Speed Selections—Maximize flexibility. Up to 39 different spindle speeds may be programmed.

Tool Selection—Programming up to 9 different tools is possible.

Tool Zero Offsets—Can be set within plus or minus .0499 inch. A much greater range of tool wear or set-up error can be compensated.

Feed-rate Override—Lets operator slow down programmed feed rate at will. Capability from 0 to 100 percent of programmed value.

Feed-hold Push Button—Allows the operator to stop the control at any time without losing synchronization. The machine resumes normal operation when the button is released.

Machine Mode Selector—Permits Mark Century 100S controls to be operated in three modes:

Automatic—All machine commands come from programmed tape.

Semi-automatic—(optional) Machine operates from commands entered by operator on manual-data-input panel.

Manual—In-out and right-left jog buttons permit servo operation of each machine axis under manual control.

Zero-position Push Button Control—Eliminates need for expensive position readout equipment. Depressing the button sets all control counters to zero dimension and causes controlled mo-

tions to operate at top feed rate until their respective zero limit switches are actuated. At this point, machine is synchronized and ready to start a contouring cycle.

Tape Parity Check—Provides for reading error or parity check of each character read from the tape. A tape error will stop all motions at the last command and illuminate a "reading error" light.

Out of Synchronism Protection—Use of automatic acceleration limit circuit prevents the difference between commanded and actual positions from exceeding a predetermined amount.

Rotary Resolver Feedback Unit—Provides precise correspondence of command signal and machine member to resolution of 0.0001 inch.

Servo Drives—Provide highly reliable operation and maximum accuracy. Provision for either silicon-controlled rectifier or electro-hydraulic servos has been made.

Control Checkout—Permits complete logic circuitry check for proper operation by means of a check tape.

Optional Features

Several optional features are provided for those applications requiring these special capabilities. They can be added easily with plug-in units and minor rewiring.

Tape Controlled Thread-cutting—Allows full N/C thread-cutting for longitudinal, face, and tapered threads—both internal and external. Maximum leads of .099999, .99999 and 1.99998 inches thread can be programmed.

Additional Pairs of Tool Offsets—Permits adding 4 pairs of tool offsets to the

standard control, making a total of 8 pairs of offsets.

Take-up Reels For Tape Reader—Provides greater tape handling capability than standard tumble box. The 4 $\frac{5}{8}$ inch diameter reels can accommodate up to 200 feet of tape.

Sequence Number Readout—Informs the operator visually of the machine operation being performed. It also gives him the ability to search out and repeat any particular machine sequence.

Manual Data Input—Enables the operator to duplicate from the console all in-

put information that can be provided from tape. This option is particularly valuable for set-up and prototype work.

Accupin* Feedback—Linear transducer provides direct measurement of machine tool position independent of rack and pinion or lead screw.

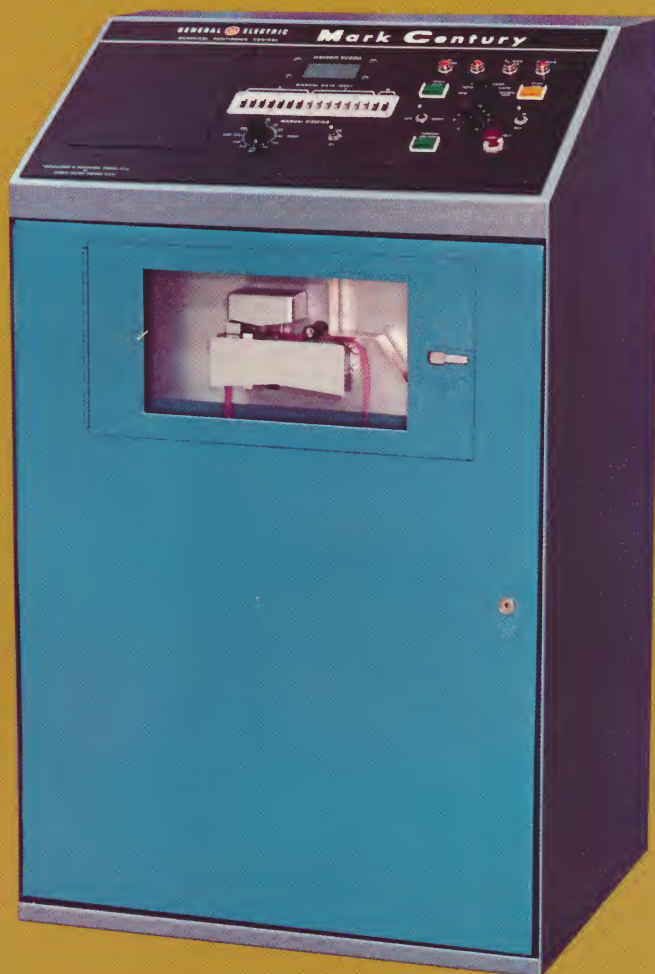
Choice of Servo Drives—Permits optimum machine/control performance. Choose either electro-hydraulic servo valve amplifiers or silicon-controlled rectifier drives to 1 hp.

* Trademark of General Electric Company

There is a Mark Century numerical control system to fit your needs whatever your performance requirements may be. See your G-E Sales Engineer, or machine-tool builder's representative for more information about General Electric numerical controls, including the new Mark Century 100S control.

Specialty Control Department, Waynesboro, Virginia

GENERAL  ELECTRIC



Mark Century* 120 Numerical Positioning Control

A packaged Mark Century two-axis system for
automatic operation of point-to-point machines

*Trademark of General Electric Company

GENERAL  ELECTRIC



Mark Century 120

numerical positioning control

easily justified by any machine tool user

Mark Century packaged numerical controls are available in several models—each tailored to a special type or group of machines. The 120 control is a two-axis system for point-to-point machines, and there are other G-E packaged systems for machines with different control requirements such as turning, boring, and milling.

All G-E packaged controls come in one basic design with a number of pre-engineered options which can be added inexpensively for extra versatility. The user benefits from this packaged design concept because he gets a high performance N/C system on machines of his choice without paying for unnecessary features.

Furthermore, all G-E packaged controls are substantially similar in design and construction. This compatibility can reduce operating costs significantly where several are in use. Training expenses are less, and overall operating efficiency is improved because of similarities in programming and maintenance.

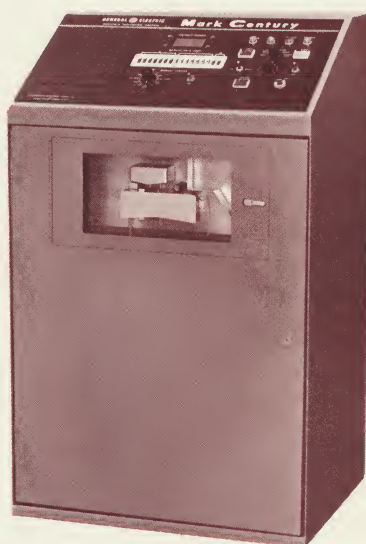
Since its introduction, the Mark Century 120 numerical control has gained wide acceptance and is offered with many types and brands of machines. The latest model of the 120 control, described here, incorporates a number of new features and improvements for added value to the user.

High reliability

Design standards and components for the Mark Century 120 control are of the same high quality found in all General Electric Mark Century controls. More than a decade of General Electric experience in designing and building numerical controls for over 100 machine-tool manufacturers backs up your assurance of reliability.

Input data is distributed, stored and acted on by solid-state circuitry. These transistorized, printed circuits—carefully designed and manufactured—give you performance and reliability you can depend on.

And because the control is machine-matched and thoroughly checked out operationally before it is delivered, installation at your plant is quick, simple.



Total service

General Electric has a full range of services available to users with machines equipped with the Mark Century 120 control. For example, specially trained G-E N/C service engineers from a network of over 50 offices are on call 24 hours a day.

This is only one part of the most complete service package found in the industry today. Other services available include:

- Training schools for your maintenance personnel
- Automatic check tapes for decoding circuits
- Unmatched product warranties
- Local stocks of replacement parts
- Complete service and instruction manuals
- Printed circuit board exchange plan
- Computer software support
- World-wide maintenance service



G-E engineers on call ready with technical assistance.

The Mark Century 120 control is designed for use on machines requiring automatic control of two motions, linear or rotary. Controlled simultaneously or sequentially, each motion has its own separate servo drive for point-to-point positioning.

Simplified programming

Binary-coded decimal data input is provided with standard EIA, 8-channel punched tape. Compatible with all conventional tape-producing facilities, the binary-coded decimal format simplifies programming.

Plus and minus programming capability permits four-quadrant machining in one set up.

Variable-block word address format means you don't have to program repetitive information in each block of data—just add the new data. This format produces shorter tapes and reading times, resulting in simplified and accurate operation.

Manual data input, as an option, is a valuable tool for set-up and prototype operations.

Maximum flexibility

Unmatched optional features add convenience and flexibility to the Mark 120 control. You get operator ease by using functionally arranged push buttons and switches—flexibility through extra functions which can be added. They include:

- Manual data input
- Sequence number readout
- Steering-milling control
- SCR servo drive control
- Accupin* linear position feedback
- Electro-hydraulic servo drive control
- Tape reader with take-up reels

A protected photoelectric tape reader provides fast, reliable operation. Proportional d-c servo drives, with silicon-controlled rectifiers or electro-hydraulic drives give the machine fast hole-to-hole positioning time.

Compact, easy to maintain

A modern NEMA 1, pressure ventilated, floor-mounted enclosure contains all control components. Machine/control connections are made with plug-in connectors, and swing-open gasketed doors provide easy access to all parts of the unit.

Plug-in printed circuit boards, clearly identified by type and plug-in receptacles, make board changing easy and foolproof. A check tape and condition indicator boards speed checkout of the control reading and data storage circuits.

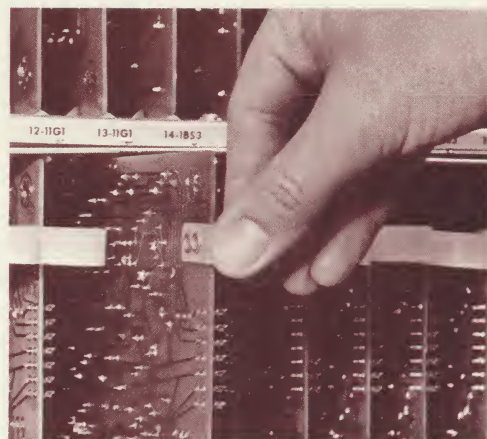
The compact Mark Century 120 positioning control measures only 28 inches wide, 22 inches deep, and 45¾ inches high. It operates on standard 230-volt, 60-cycle power with a $\pm 10\%$ voltage variation permissible.

Control transformers are available for operation with other conventional 60 and 50 cycle voltages.

* Trademark of General Electric Co.

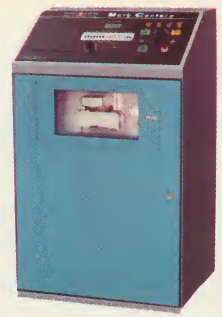


Functionally arranged panel controls provide utmost convenience and flexibility.



Mark Century 120

numerical positioning control



Standard Features

Plus and Minus Programming—Allows the X and Y motions to be programmed on either side of the zero reference which has been established.

Absolute Data Input—The Mark Century 120 positioning unit provides control of two axes simultaneously with a maximum command of ± 99.9999 inches of each axis. The command input is in absolute dimensions.

Resolution—Minimum input dimension is 0.0001" permitting highly accurate machine operation.

Servo Drives—SCR motor ratings from 1/50 horsepower to 1 horsepower are available. These smaller motor sizes open up new application possibilities.

Straight-line Milling—Truly proportional d-c servo drives permit milling along any machine axis. Milling feed rate

over a 100:1 range can be easily controlled by the operator with a convenient panel-mounted potentiometer.

Zero Offset—Makes it possible to locate the zero point of the control system at any point on the machine table for added set-up flexibility.

Backlash Take-up—Positioning is more accurate because effects of backlash, windup or other lost motion of the machine are eliminated. A backlash take-up circuit for each motion provides for final positioning from the same direction regardless of the previous position.

Rotary Resolver Feedback—Provides precise correspondence of command signal and machine-tool position.

Machine-mode Selection—Mark Century 120 controls can be operated in three modes:

Automatic — All machine com-

mands come from programmed tape.

Semi-automatic — (Optional) Machine operates from commands entered by operator on manual-data-input panel.

Manual — Right-left, in-out jog switches permit servo operation of each machine axis under manual control.

Broad Range of Auxiliary Functions—As part of the standard control, 99 miscellaneous functions are available to the machine builder. This built-in flexibility means the machine you buy has a full range of auxiliary operations that can be programmed, including feeds, speeds and depth stops, tool selection, and other assigned functions.

Optional Features

Full two-axis positioning capability is provided with the standard features of the Mark Century 120 control. Optional features are provided for those applications requiring these capabilities.

Manual Data Input—Enables the operator to duplicate from the console all input information that can be provided from tape. This option is particularly valuable for set-up and prototype work.

Sequence Number Readout—This display indicates the operation being accomplished by the machines, and provides a reference to the operator

for initiating certain manual operations such as tool or gear change. It also gives him the ability to locate and repeat any particular machine sequence.

Choice of Servo Drives—Silicon-controlled rectifier servo drives rated up to one horsepower can be furnished. For larger machines, electro-hydraulic servo drives are available optionally at no increase in price of the basic control unit. These hydraulic servo drives contribute to the efficiency of such high speed applications as punching machines.

Steering-milling Control—Allows rough milling under manual operation. The

operator sets the desired milling feed and, with the steering control, determines the direction of feed. Accuracy of the path depends on the mill feed rate and the skill of the operator.

Accupin Linear Transducer—Provides direct measurement of machine-tool position independent of rack and pinion or lead screw.

Take Up Reels For Tape Reader—Provides reader with greater tape handling capability. 4 5/8 inch diameter reels can accommodate up to 200 feet of tape.

No matter what your performance requirements may be, there is a Mark Century numerical-control system to fit your needs. See your G-E Sales Engineer or machine-tool builder's representative for more information about Mark Century control systems, including the new Mark Century 120 positioning control.

Specialty Control Department, Waynesboro, Va.

GENERAL  ELECTRIC

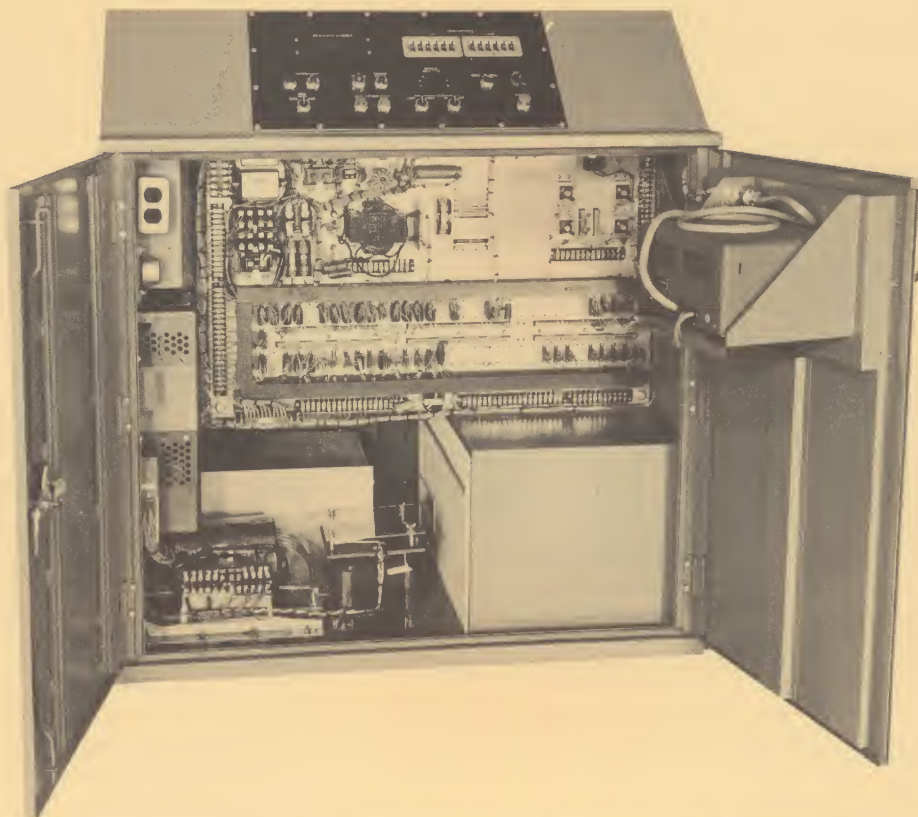
MARK CENTURY

PROVEN NUMERICAL CONTROL---NEW SERVICE CONCEPT

GENERAL  ELECTRIC

MARK CENTURY* NU

Proven product benefits



Mark Century numerical control systems are industrially rugged, **to meet electrical standards** of the National Machine Tool Builder's Association . . . and more. Construction features include **oil-tight pushbuttons and switches** for all operator functions. Connections are made to machine-mounted elements by plugs and receptacles **inside** the control enclosure.

Circuitry is **completely solid state**, with all components mounted on printed-circuit boards, functionally arranged and easily accessible in swingout panels. Built-in **air conditioning** assures optimum performance even in an adverse environment.

Performance, though, is where Mark Century gives you the biggest return for your numerical control investment. **System resolution is 0.0001 inch** and does not change with feed speed.

Also, Mark Century accepts data in **Binary Coded Decimal form** and does not convert it. You can read the information internally in the same form as it was introduced by the tape, making check-out easier.

The **circular interpolation** feature of Mark Century contouring control can save computer time or simplify programming when a desk computer is used.

With Mark Century you can also take advantage of **APT programming** because General Electric furnishes GECENT, a very sophisticated generalized APT post-processor program.

Mark Century can automatically **control multiple, simultaneous** motions of the machine tool. Yet, your operator has complete control from the console: (1)

He can **manually perform any tape operation**. (2) **Adjust feed-rate** to compensate for differences in material with an over-ride dial. (3) **Stop the machine without losing synchronization**. (4) Easily **produce mirror images** with a "Normal/Reverse" selector switch for each axis. (5) Check-out the entire system in one to five minutes with a G-E furnished **check tape**.

General Electric offers a complete line of **electric- or hydraulic-servo drives** for both positioning and contouring applications. The same is true of **feedback devices**, ranging from the standard rotary resolver, which rotates by gearing with the machine's motion, to the optional Accupint[†], which mounts directly on the machine's moving member. Both are accurate to 0.0001 inch. **Tachometer velocity feedback** in the servo system has the unique characteristic of correcting very small errors before they show up in the work piece.

In addition, you can choose from a large number of options for your special needs:

- **By tape command alone** you can cut right- or left-hand threads, tapered or variable-pitch threads.
- **"Zero offset"** dials let you adjust program starting point on the machine after synchronization.
- **Position readout** is done from a display of six digits and plus or minus signs for each motion.
- **Sequence number readout** gives operator a quick reference to the manuscript.
- **Photoelectric reader** reads at high-speed rate of 400 characters per second.

*Trade Mark of General Electric Co. †Reg. Trade Mark of General Electric Co.

AMERICAN NUMERICAL CONTROL

New service concept

A new service program combines expertness of the factory engineer with the availability of a nationwide organization. Over 100 Mark Century Service Engineers—trained and experienced as numerical control specialists—are in place in 43 strategically located cities, including all major machine-tool manufacturer locations.

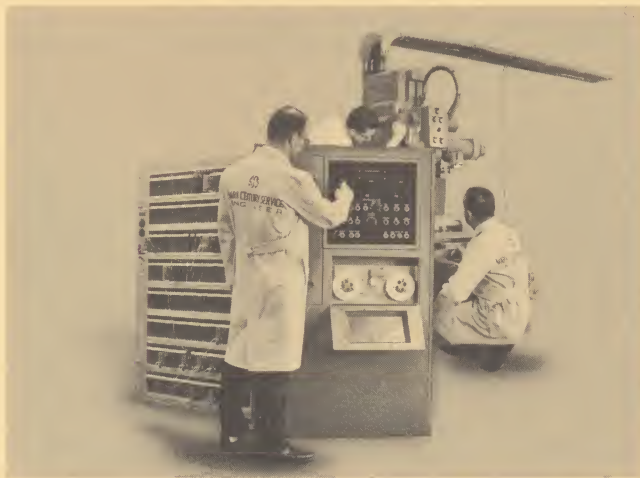


When the control arrives at the machine-tool manufacturer's, the Mark Century Service Engineers thoroughly **check-out** the machine/control system. If the system is new in their area, they will already have been back to the factory for **special training**. There, they become intimately familiar with the new system by taking part in the last few weeks of manufacturing and testing.

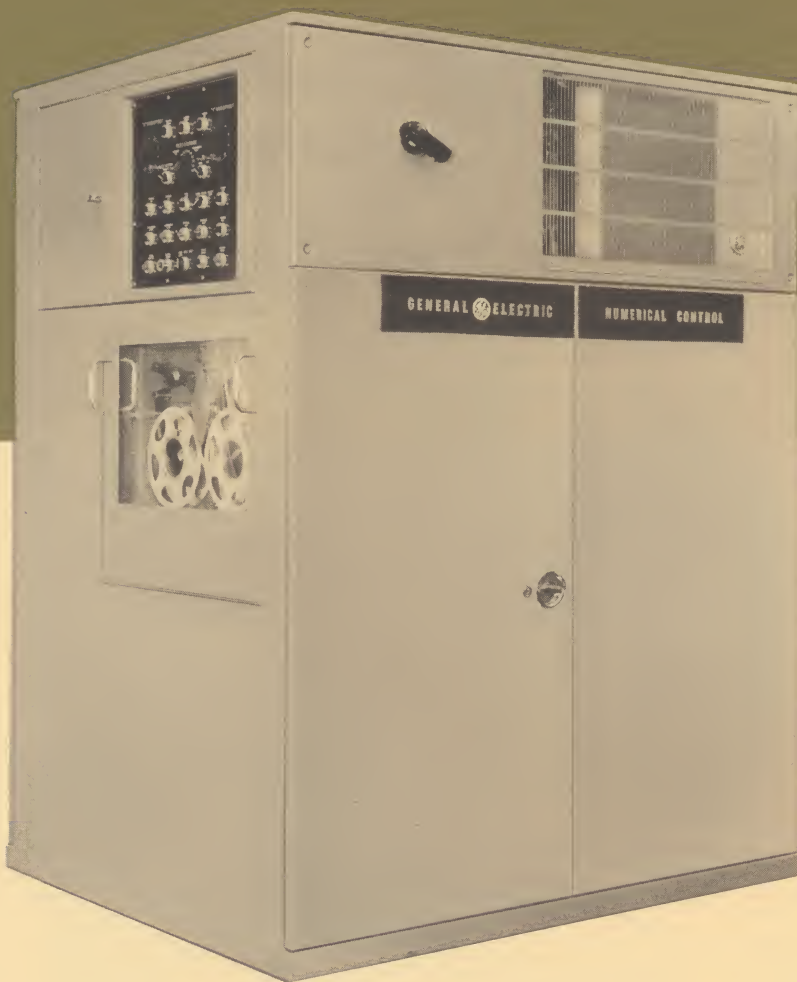
While machine and control are still at the manufacturer's, the Mark Century team prepares a **critical path diagram** for every phase of the start-up. To complete the check-out, the Service Engineers help the machine builder verify your machine/control operation with a **check tape**.

This careful planning is designed to make a fast start-up at your plant routine. The pre-planning, which gets you **on-line in minimum time**, means you get an immediate added profit by having your investment paying for itself sooner.

The start-up in your plant will be supervised by a local Mark Century Service Engineer qualified on the particular machine/control through experience or special training. This way, you can expect expert follow-up service from a man available locally who will also make **regular checks** to see that your system is operating properly. As an additional service, General Electric operates **factory training schools** for your numerical control maintenance people.



JOB-PROVED NUMERICAL CONTROL YOU CAN SPECIFY WITH CONFIDENCE



General Electric's unmatched experience gets your machine/control system on-line fast. Integration is smooth because General Electric has worked closely with every major machine-tool manufacturer—nearly 40 in all—in building control systems.

Applications include positioning, contouring, and combination positioning-contouring control on every basic type of machine tool.

Combine this total and varied experience with a comprehensive service plan and Mark Century adds up to the most complete quality package you can buy.

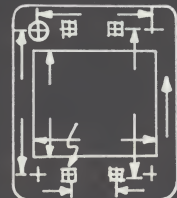
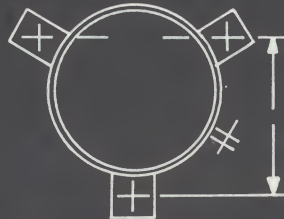
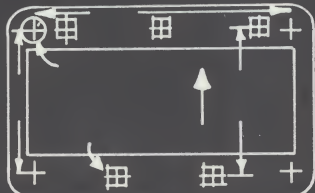
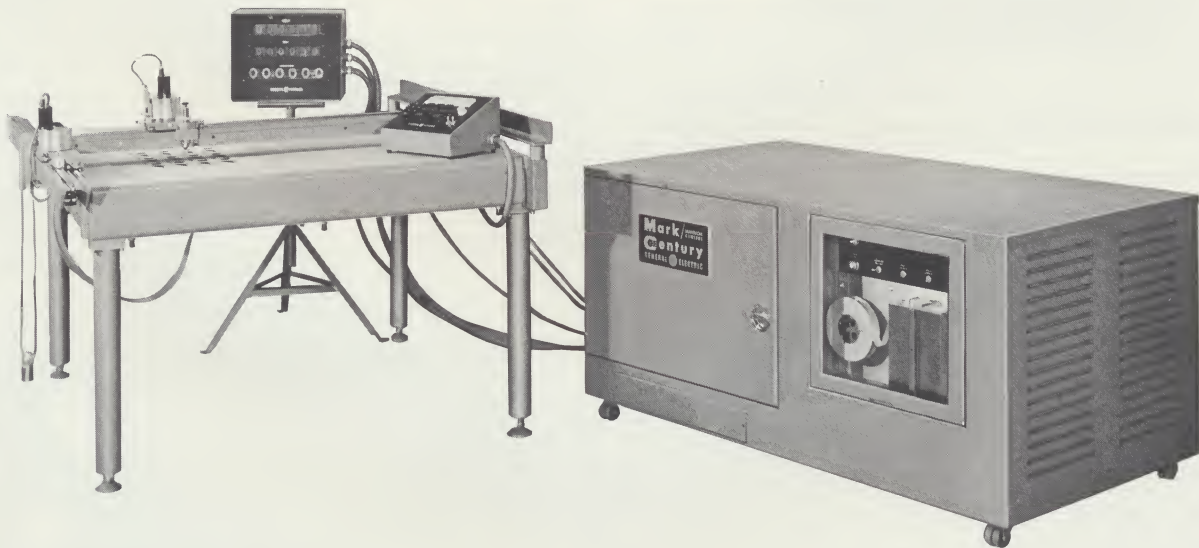
GENERAL  ELECTRIC

SPECIALTY CONTROL DEPARTMENT, WAYNESBORO, VIRGINIA



Mark Century* Autoprogrammer* System

for automatic preparation of punched tape programs direct from undimensioned drawings



GENERAL  ELECTRIC

* Trade-marks of General Electric Co.



Mark Century Autoprogrammer system prepares N/C machine tool tapes fast and at low cost...cuts drafting time up to 75 percent

An important link is added to the numerical control concept—automatic preparation of one-inch, eight-channel punched tape made direct from undimensional scale drawings or reproductions. Tape—prepared by General Electric's new Mark Century Autoprogrammer systems—is ready for use immediately after programming. No additional processing is needed.

The Autoprogrammer system eliminates costly and time-consuming dimensioning of drawings and the possible associated errors. Drawing-to-shop lead time is shortened by a reduction of up to 75 percent in drafting time. Maximum utilization of numerically controlled equipment becomes possible.

Positioning information is obtained from scale drawing templates or layouts. Depth dimensions and auxiliary function information (such as coolant on, position, don't punch, etc.) are added at the console by an operator. The Autoprogrammer system translates this information into the punched tape.

AUTOGRAMMER SYSTEM FEATURES

- Eliminates need for special drafting and dimensioning techniques.
- Eliminates need for writing and typing program manuscripts.
- Precision digital encoders establish the X and Y co-ordinates of the stylus location to within 0.001 inch.
- Digital values are displayed and encoded on standard one-inch, eight-channel tape, per EIA standards.
- Manual keyboard permits encoding all auxiliary functions such as feed, speed, and tool selection words.
- Operation is easy and requires no special training.
- Undimensioned drawings may be $\frac{1}{4}$, $\frac{1}{2}$, twice or four times full size. Electrical switch selects desired scale in seconds. No gear changes required.
- Prepared tape conforms with EIA specification RS-227, dated October 1959. Character coding conforms with EIA specification RS-244, dated July, 1961.

WHERE TO USE

The Mark Century Autoprogrammer system can be used with G-E Mark Century numerical control or other

N/C systems. Logic circuits within the Autoprogrammer system use the same circuit boards as other Mark Century controls.

ECONOMIC JUSTIFICATION

Reductions in drafting time, program preparation, manuscript writing, and tape-punch typing of the manuscript are significant enough to pay for an Autoprogrammer system within two years for many applications. Most significant saving is up to 75 percent reduction in drafting time, which is the principle factor in justifying the investment.

A G-E sales representative can help you with more details on an audit of savings realized with an Autoprogrammer system.

SYSTEM COMPONENTS

The Mark Century Autoprogrammer system has four basic components—main control enclosure, which contains the logic elements for converting table position or keyboard information into signals that operate the tape punch; operator console; position read-



OPERATOR CONSOLE—This movable unit connects to the main control by a 10 foot cable. Through this unit the operator can program sequence numbers and auxiliary commands; can add hole locations or dimensions not shown on the drawing; can reset dimension registers to zero and command the tape punch to space, delete, backspace, or feed.

out panel; and a precision layout table fitted with position sensing devices and an eyepiece for locating drawing references.

The layout table may be supplied by either the customer or as part of the General Electric system.

OPERATION

1. On the main control panel the operator makes the initial set-up, including selection of scale and axis designation.

2. Drawings — which need not be dimensioned — are placed on the layout table.

3. Then the stylus is positioned over a zero reference point on the drawing and the axes of the drawing are adjusted so they are parallel with the axes of the Autoprogrammer system.

4. The operator then positions the stylus over the first point on the drawing. The co-ordinates of this point will be continuously displayed in the readout, throughout that sequence. Point locations (hole centers, etc.) are read from the drawings by the sensors. Hole sizes and drilling depths not shown on the drawing can be added by the operator at the portable key-board.

5. After inserting the tape into the punch, the operator can then set-up the first sequence. If required, a sequence number may be introduced into the tape by depressing an address letter and appropriate digits on the operator console. The information is punched into the tape, and at the same time, displayed and retained in the readout for visual check.

6. The X and Y co-ordinate information then is automatically punched into the tape as the stylus is

used to scan the dimensionless drawing on the layout board. Auxiliary commands such as spindle speed and turret speed can be given by the operator by depressing appropriate address letters on the operator console.

7. After the first sequence is completed, a new sequence number is entered by the operator and the procedure is repeated.

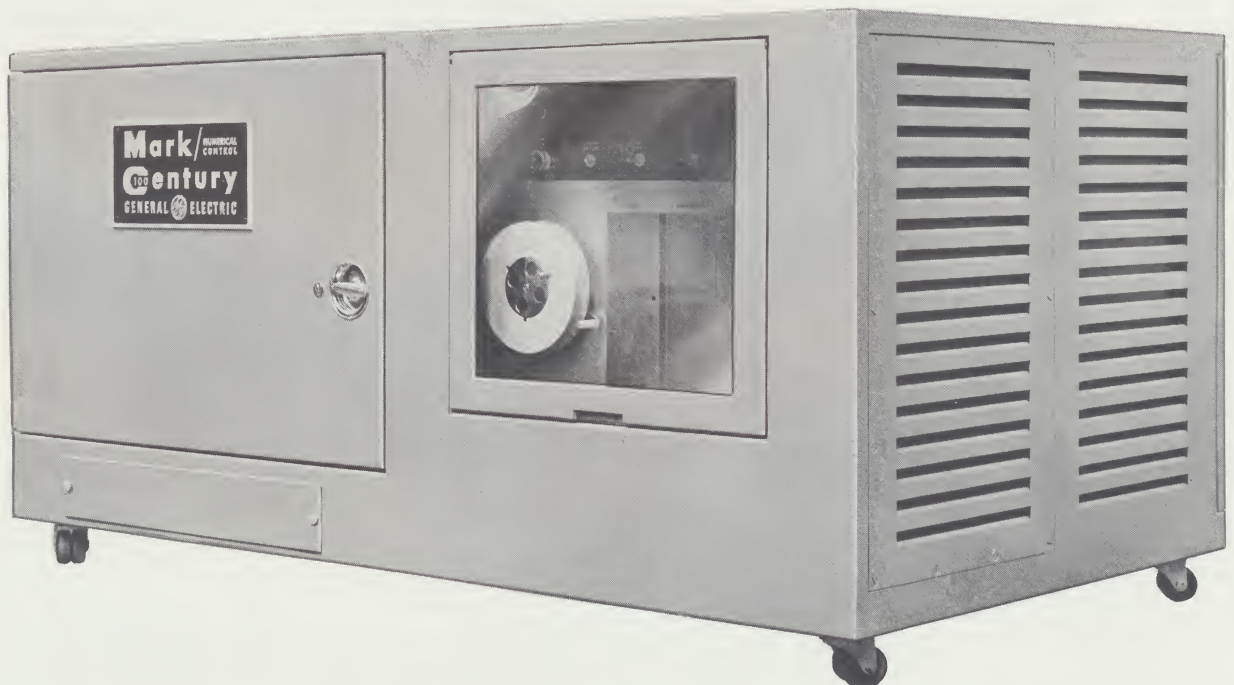
8. Auxiliary information needs to be punched only when it changes from previous stops. And holes which have dimensions unchanged from previous ones need no new dimensions punched into the tape.

9. If an error is made by the operator and the wrong information is recorded, the tape can be backed up to the point where the error was made. The error is cancelled, and new information is entered on the tape.

10. As soon as all information from the drawing has been entered, the tape is ready for use.



POSITION READOUT PANEL—The readout station has a six-digit readout for each axis and a six-digit manual data readout. It can be wall or floor mounted.



MAIN CONTROL ENCLOSURE—This unit houses the set-up panel, tape punch, solid state logic circuitry, test panel, power supply, and various support elements.



Mark Century Autoprogrammer system prepares N/C machine tool tapes fast and at low cost...cuts drafting time up to 75 percent

An important link is added to the numerical control concept—automatic preparation of one-inch, eight-channel punched tape made direct from undimensional scale drawings or reproductions. Tape—prepared by General Electric's new Mark Century Autoprogrammer systems—is ready for use immediately after programming. No additional processing is needed.

The Autoprogrammer system eliminates costly and time-consuming dimensioning of drawings and the possible associated errors. Drawing-to-shop lead time is shortened by a reduction of up to 75 percent in drafting time. Maximum utilization of numerically controlled equipment becomes possible.

Positioning information is obtained from scale drawing templates or layouts. Depth dimensions and auxiliary function information (such as coolant on, position, don't punch, etc.) are added at the console by an operator. The Autoprogrammer system translates this information into the punched tape.

AUTOGRAMMER SYSTEM FEATURES

- Eliminates need for special drafting and dimensioning techniques.
- Eliminates need for writing and typing program manuscripts.
- Precision digital encoders establish the X and Y co-ordinates of the stylus location to within 0.001 inch.
- Digital values are displayed and encoded on standard one-inch, eight-channel tape, per EIA standards.
- Manual keyboard permits encoding all auxiliary functions such as feed, speed, and tool selection words.
- Operation is easy and requires no special training.
- Undimensioned drawings may be $\frac{1}{4}$, $\frac{1}{2}$, twice or four times full size. Electrical switch selects desired scale in seconds. No gear changes required.
- Prepared tape conforms with EIA specification RS-227, dated October 1959. Character coding conforms with EIA specification RS-244, dated July, 1961.

WHERE TO USE

The Mark Century Autoprogrammer system can be used with G-E Mark Century numerical control or other

N/C systems. Logic circuits within the Autoprogrammer system use the same circuit boards as other Mark Century controls.

ECONOMIC JUSTIFICATION

Reductions in drafting time, program preparation, manuscript writing, and tape-punch typing of the manuscript are significant enough to pay for an Autoprogrammer system within two years for many applications. Most significant saving is up to 75 percent reduction in drafting time, which is the principle factor in justifying the investment.

A G-E sales representative can help you with more details on an audit of savings realized with an Autoprogrammer system.

SYSTEM COMPONENTS

The Mark Century Autoprogrammer system has four basic components—main control enclosure, which contains the logic elements for converting table position or keyboard information into signals that operate the tape punch; operator console; position read-



OPERATOR CONSOLE—This movable unit connects to the main control by a 10 foot cable. Through this unit the operator can program sequence numbers and auxiliary commands; can add hole locations or dimensions not shown on the drawing; can reset dimension registers to zero and command the tape punch to space, delete, backspace, or feed.

out panel; and a precision layout table fitted with position sensing devices and an eyepiece for locating drawing references.

The layout table may be supplied by either the customer or as part of the General Electric system.

OPERATION

1. On the main control panel the operator makes the initial set-up, including selection of scale and axis designation.

2. Drawings — which need not be dimensioned — are placed on the layout table.

3. Then the stylus is positioned over a zero reference point on the drawing and the axes of the drawing are adjusted so they are parallel with the axes of the Autoprogrammer system.

4. The operator then positions the stylus over the first point on the drawing. The co-ordinates of this point will be continuously displayed in the readout, throughout that sequence. Point locations (hole centers, etc.) are read from the drawings by the sensors. Hole sizes and drilling depths not shown on the drawing can be added by the operator at the portable key-board.

5. After inserting the tape into the punch, the operator can then set-up the first sequence. If required, a sequence number may be introduced into the tape by depressing an address letter and appropriate digits on the operator console. The information is punched into the tape, and at the same time, displayed and retained in the readout for visual check.

6. The X and Y co-ordinate information then is automatically punched into the tape as the stylus is

used to scan the dimensionless drawing on the layout board. Auxiliary commands such as spindle speed and turret speed can be given by the operator by depressing appropriate address letters on the operator console.

7. After the first sequence is completed, a new sequence number is entered by the operator and the procedure is repeated.

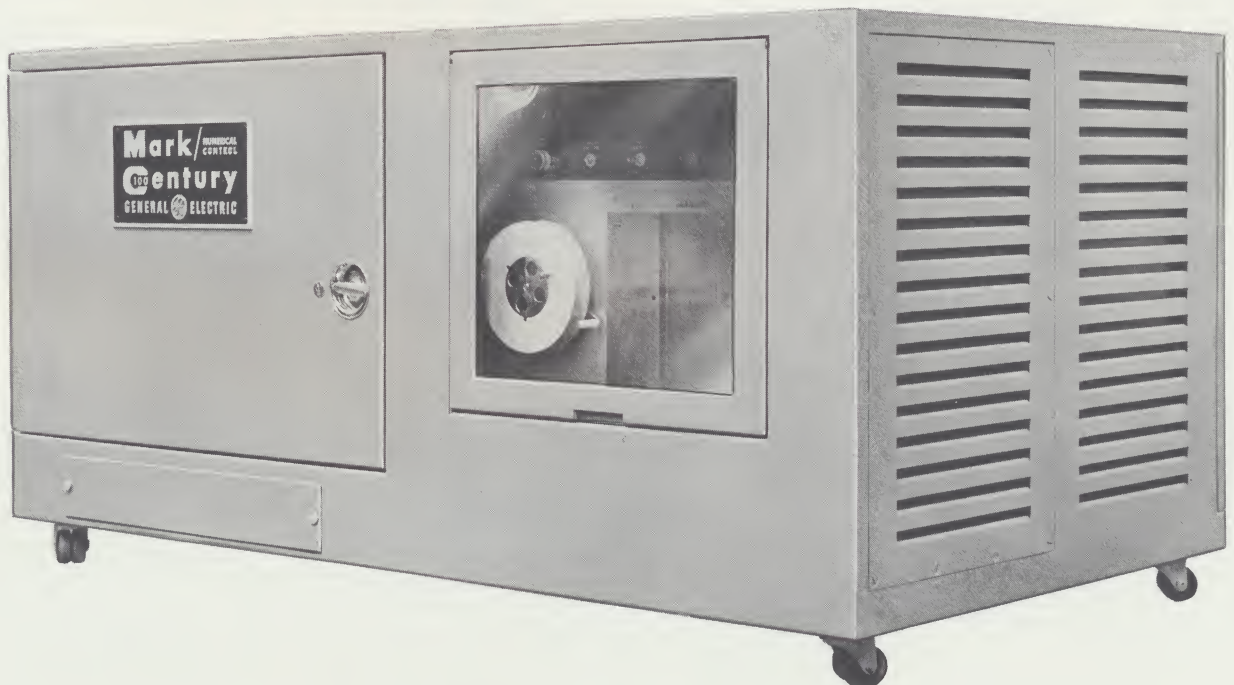
8. Auxiliary information needs to be punched only when it changes from previous stops. And holes which have dimensions unchanged from previous ones need no new dimensions punched into the tape.

9. If an error is made by the operator and the wrong information is recorded, the tape can be backed up to the point where the error was made. The error is cancelled, and new information is entered on the tape.

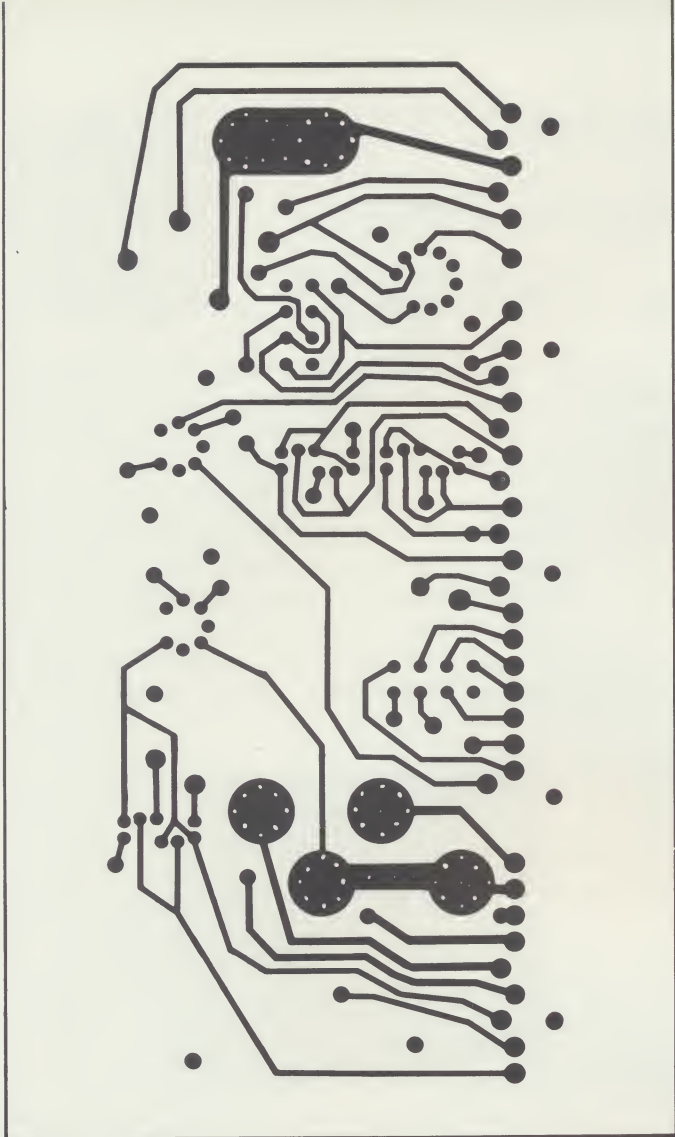
10. As soon as all information from the drawing has been entered, the tape is ready for use.



POSITION READOUT PANEL—The readout station has a six-digit readout for each axis and a six-digit manual data readout. It can be wall or floor mounted.



MAIN CONTROL ENCLOSURE—This unit houses the set-up panel, tape punch, solid state logic circuitry, test panel, power supply, and various support elements.

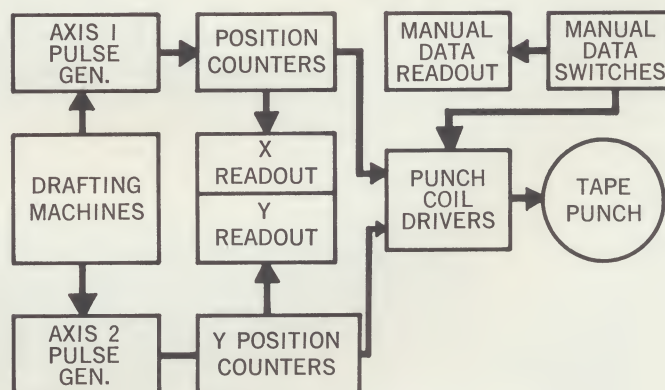


Printed circuit board . . . typical of parts that can be programmed by Autoprogrammer System.

AUTOPROGRAMMER SYSTEM SPECIFICATIONS

- Standard table size 48" x 48". Larger table available as an option.
- Scale ratios of $\frac{1}{4}$ to 1, $\frac{1}{2}$ to 1, 2 to 1, and 4 to 1 are available by selector switch setting.
- Round off feature is included to encode dimension to nearest 0.1 inch when desired.
- Equipment operates from 120 volts, 60 cycles, single phase.
- Ten amp circuit breaker is built in.
- A portable operator's console (12" x 9" x 7") is provided so that it may be moved to suit the operator's convenience.
- A position readout panel is provided containing three projection-type readouts. Two are for the table co-ordinates and the third is to display the auxiliary function words which are encoded manually.

MARK CENTURY AUTOPROGRAMMER



For ordering assistance or for more information on the Mark Century Autoprogrammer systems, contact your General Electric Sales Office, or Machinery Automation Sales, Specialty Control Dept., Waynesboro, Virginia.

Progress Is Our Most Important Product

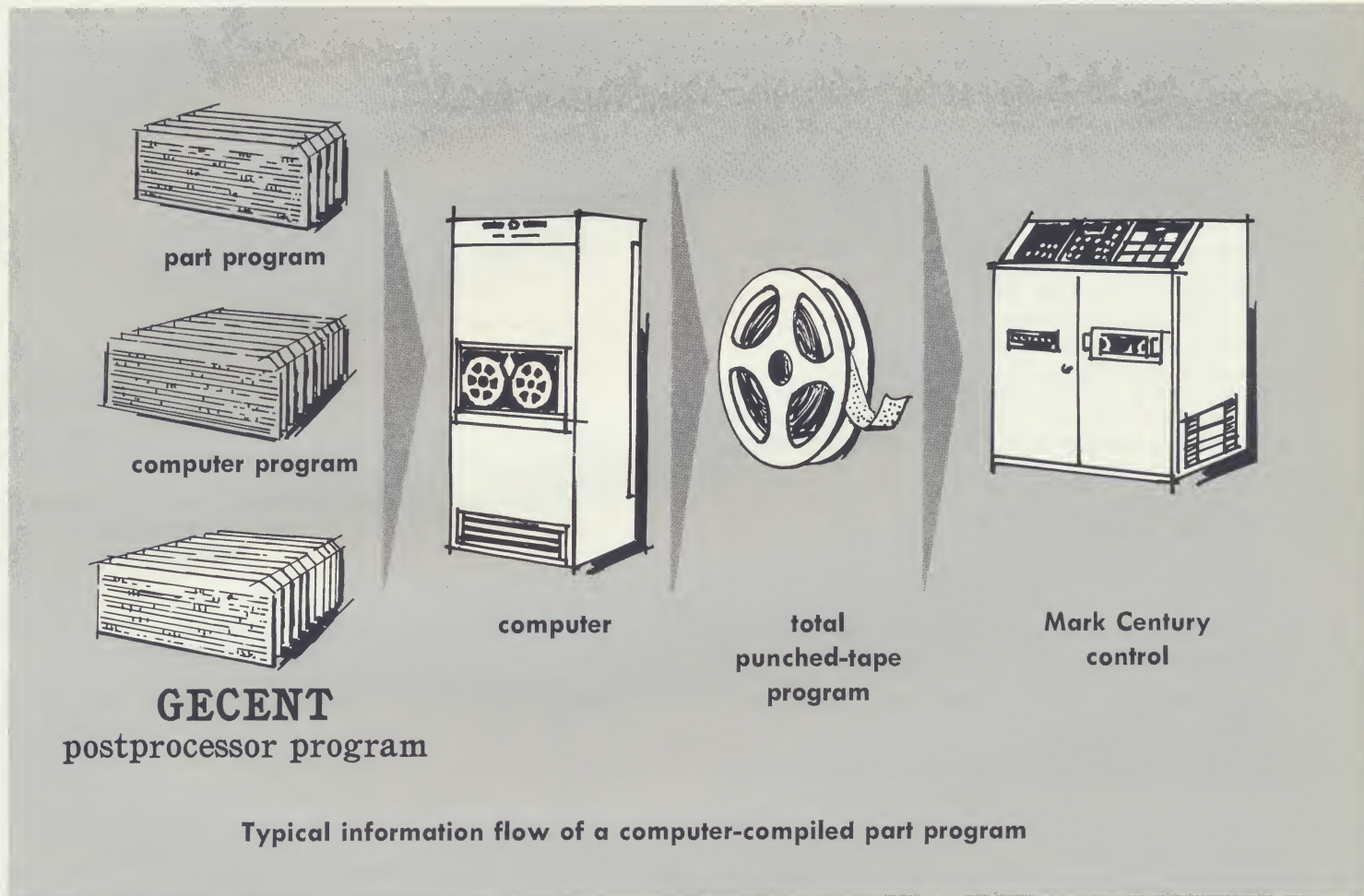
GENERAL  ELECTRIC

SPECIALTY CONTROL DEPT., WAYNESBORO, VIRGINIA



GECENT* postprocessor

an APT III computer program
for Mark Century* numerical controls



- completely generalized format
- FORTRAN language
- up to 500 error diagnostics
- APT II system adaptability

The GECENT postprocessor, written by the General Electric Company for its Mark Century numerical controls, is designed for use with the APT III (Automatically Programmed Tools) numerical control computer program system.

In the APT III system, a part program written in APT language describes the machine tool operations

necessary for production of a particular part. An APT computer program provides the "intelligence" necessary for a general-purpose computer to accept and understand the part program instructions and to calculate the coordinate points to be followed by the machine tool cutter. The GECENT postprocessor reprocesses cutter-location data and puts spindle speeds, feedrates, and auxiliary commands in the output form necessary for a specific tool with Mark Century control to machine the desired part. Tapes are prepared in the AIA-EIA format or to other individual requirements.

* Trade-mark of the General Electric Company

GENERAL  ELECTRIC

Designed for solid-state controls

The GECENT postprocessor was the first program available for second-generation, solid-state controls with circular interpolation capability. Members of the APT Long Range Program received the postprocessor in September, 1962, several months before other such programs were issued.

Applies to various machine tools

Previous postprocessors were written for individual machine tools, requiring expensive and complicated technical modification for application to different machines. The GECENT postprocessor has a completely generalized format and serves many machines with a single program.

Presently, over 15 different types of machine tools including point-to-point drilling, 3-axis profile milling, 2-axis drafting machines, and lathes are operated by this postprocessor.

The GECENT program is the only postprocessor available for engine and turret lathes and includes routines for constant-surface cutting speed, constant chip thickness, linear and variable lead threading, and tapered and facing threads. Subroutines can even coordinate the motions of separate tool holders.

Certain other postprocessors outside the GECENT program's framework are available for use with 5-axis contouring machines and Mark Century controls. However, work now in process will extend the GECENT program to cover 4- and 5-axis contouring machines including vertical-turret lathes with simultaneous operation of two heads.

Reduces investment cost

Postprocessors for a single machine cost anywhere from 20 to 50 thousand dollars to write. Since they are not easily modified, upkeep involves further expense, making the cost of a complete individual-machine-postprocessor library extremely high.

The GECENT program can be used with almost any machine, thus the investment cost for the postprocessor is low. Changes in the postprocessor to meet non-standard machine requirements are also inexpensive since the GECENT format can be easily altered.

Written in FORTRAN

The GECENT program utilizes the universal computer language FORTRAN. This means any suitable computer can recognize the GECENT postprocessor.

Total vocabulary is 45 postprocessor word-state-ments.

Should the GECENT program need revision or updating, its generalized format and modular construction permit this to be done easily. This is not possible with most other postprocessors.

Saves computer and production time

With the GECENT postprocessor, there is a minimum of data shifting during storage, resulting in a saving of computer time usually required in processing part programs.

The circular interpolation routine speeds production time by reducing tape length and machine tool cycle time.

Because of the capability for stacking programs, only one computer loading is necessary for preparation of an output tape for as many as 10 different machines capable of producing a desired part. This means manufacturing operations can choose any suitable machine available at the time the part is needed or switch to an alternate machine in case of original machine breakdown.

Detects and analyzes errors

Each output statement is checked several times for accuracy. But, should a program hang up, 1 of over 500 error diagnostics built into the GECENT postprocessor indicates not only the subroutine where the error occurred, but the place within the subroutine, the type of error, and in some cases, the corrective action needed.

Completely documented

Analysis of the GECENT postprocessor program is made easy by complete documentation, following standards of the APT Long Range Program.

Achieves optimum feedrates

The GECENT postprocessor contains a new A/D (acceleration-deceleration) routine. Other postprocessors use a fixed increment of feedrate change to reduce programmed feedrate to a low (5 to 10 ipm) value in a series of stair-steps when a change-of-tool direction is required.

Mark Century controls do not normally require a reduction of feedrate at corners. In those few instances when a reduction of feedrate is necessary to maintain a specified tolerance band, the GECENT A/D routine allows feedrate to be altered in one step. Feedrate modification occurs as little in advance of tool-path change as is necessary to provide proper cornering.

Supplements APT III system; compatible with APT II

The GECENT program was written as a supplement to the APT III computer program, but it will also serve the previous APT II version.

For those users who have not converted their operations, the OLDAPT subroutine links the GECENT postprocessor with the older APT II release.

It is General Electric's intention to keep the GECENT postprocessor up to date with APT standard changes.

Available now from General Electric

The General Electric Company has combined its talents as part programmer, computer programmer, control builder and user in writing the GECENT postprocessor. After being thoroughly field checked, the GECENT program is now in extensive use.

The GECENT postprocessor can help you increase profits by reducing operating costs for numerically controlled machine tools. For information on how to obtain this postprocessor, contact your nearest General Electric Industrial Sales Office.

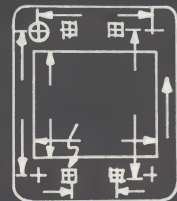
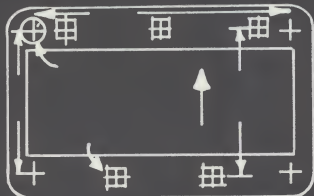
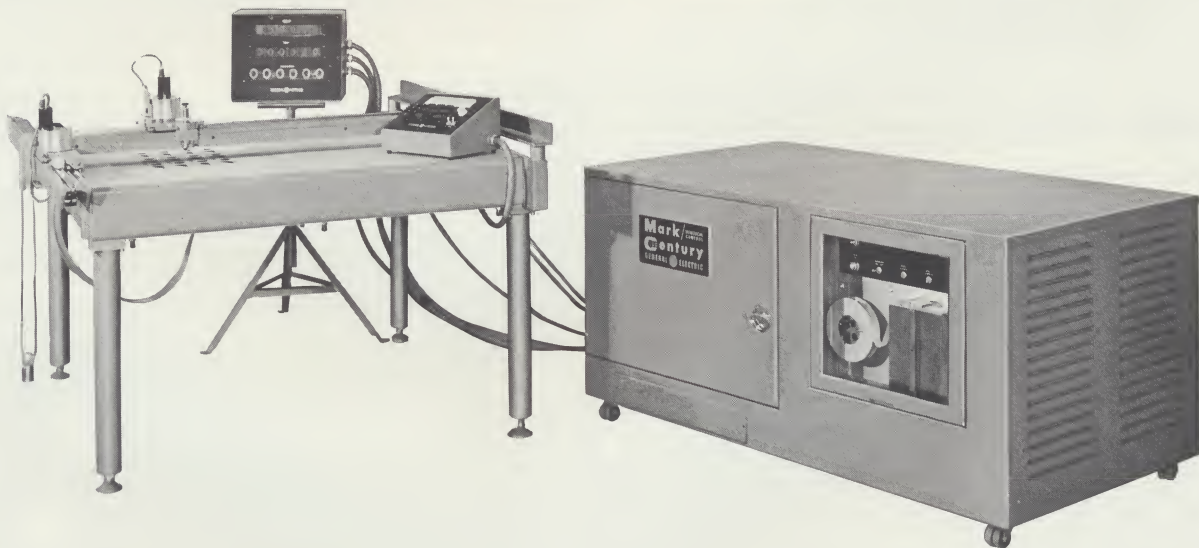


SPECIALTY CONTROL DEPARTMENT, WAYNESBORO, VIRGINIA



Mark Century* Autoprogrammer* System

for automatic preparation of punched tape programs direct from undimensioned drawings



GENERAL  ELECTRIC

* Trade-marks of General Electric Co.



Mark Century Autoprogrammer system prepares N/C machine tool tapes fast and at low cost...cuts drafting time up to 75 percent

An important link is added to the numerical control concept—automatic preparation of one-inch, eight-channel punched tape made direct from undimensional scale drawings or reproductions. Tape—prepared by General Electric's new Mark Century Autoprogrammer systems—is ready for use immediately after programming. No additional processing is needed.

The Autoprogrammer system eliminates costly and time-consuming dimensioning of drawings and the possible associated errors. Drawing-to-shop lead time is shortened by a reduction of up to 75 percent in drafting time. Maximum utilization of numerically controlled equipment becomes possible.

Positioning information is obtained from scale drawing templates or layouts. Depth dimensions and auxiliary function information (such as coolant on, position, don't punch, etc.) are added at the console by an operator. The Autoprogrammer system translates this information into the punched tape.

AUTOGRAMMER SYSTEM FEATURES

- Eliminates need for special drafting and dimensioning techniques.
- Eliminates need for writing and typing program manuscripts.
- Precision digital encoders establish the X and Y co-ordinates of the stylus location to within 0.001 inch.
- Digital values are displayed and encoded on standard one-inch, eight-channel tape, per EIA standards.
- Manual keyboard permits encoding all auxiliary functions such as feed, speed, and tool selection words.
- Operation is easy and requires no special training.
- Undimensioned drawings may be $\frac{1}{4}$, $\frac{1}{2}$, twice or four times full size. Electrical switch selects desired scale in seconds. No gear changes required.
- Prepared tape conforms with EIA specification RS-227, dated October 1959. Character coding conforms with EIA specification RS-244, dated July, 1961.

WHERE TO USE

The Mark Century Autoprogrammer system can be used with G-E Mark Century numerical control or other

N/C systems. Logic circuits within the Autoprogrammer system use the same circuit boards as other Mark Century controls.

ECONOMIC JUSTIFICATION

Reductions in drafting time, program preparation, manuscript writing, and tape-punch typing of the manuscript are significant enough to pay for an Autoprogrammer system within two years for many applications. Most significant saving is up to 75 percent reduction in drafting time, which is the principle factor in justifying the investment.

A G-E sales representative can help you with more details on an audit of savings realized with an Autoprogrammer system.

SYSTEM COMPONENTS

The Mark Century Autoprogrammer system has four basic components—main control enclosure, which contains the logic elements for converting table position or keyboard information into signals that operate the tape punch; operator console; position read-



OPERATOR CONSOLE—This movable unit connects to the main control by a 10 foot cable. Through this unit the operator can program sequence numbers and auxiliary commands; can add hole locations or dimensions not shown on the drawing; can reset dimension registers to zero and command the tape punch to space, delete, backspace, or feed.

out panel; and a precision layout table fitted with position sensing devices and an eyepiece for locating drawing references.

The layout table may be supplied by either the customer or as part of the General Electric system.

OPERATION

1. On the main control panel the operator makes the initial set-up, including selection of scale and axis designation.

2. Drawings — which need not be dimensioned — are placed on the layout table.

3. Then the stylus is positioned over a zero reference point on the drawing and the axes of the drawing are adjusted so they are parallel with the axes of the Autoprogrammer system.

4. The operator then positions the stylus over the first point on the drawing. The co-ordinates of this point will be continuously displayed in the readout, throughout that sequence. Point locations (hole centers, etc.) are read from the drawings by the sensors. Hole sizes and drilling depths not shown on the drawing can be added by the operator at the portable key-board.

5. After inserting the tape into the punch, the operator can then set-up the first sequence. If required, a sequence number may be introduced into the tape by depressing an address letter and appropriate digits on the operator console. The information is punched into the tape, and at the same time, displayed and retained in the readout for visual check.

6. The X and Y co-ordinate information then is automatically punched into the tape as the stylus is

used to scan the dimensionless drawing on the layout board. Auxiliary commands such as spindle speed and turret speed can be given by the operator by depressing appropriate address letters on the operator console.

7. After the first sequence is completed, a new sequence number is entered by the operator and the procedure is repeated.

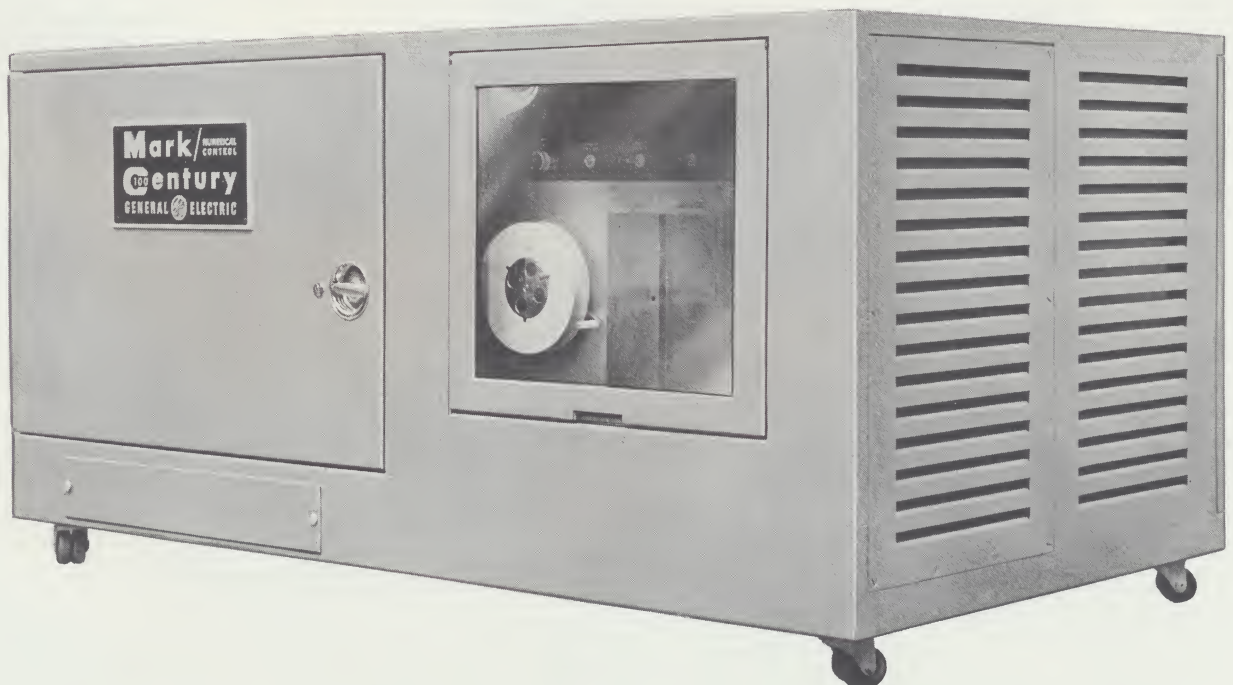
8. Auxiliary information needs to be punched only when it changes from previous stops. And holes which have dimensions unchanged from previous ones need no new dimensions punched into the tape.

9. If an error is made by the operator and the wrong information is recorded, the tape can be backed up to the point where the error was made. The error is cancelled, and new information is entered on the tape.

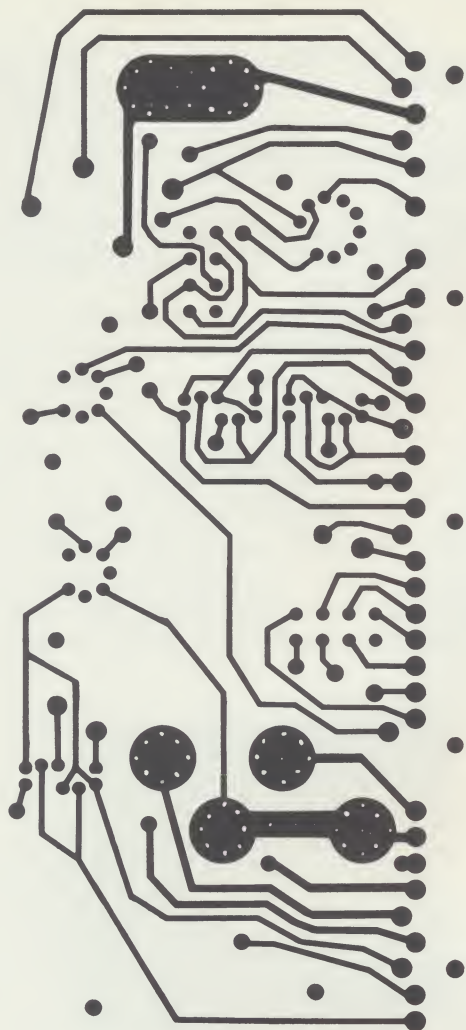
10. As soon as all information from the drawing has been entered, the tape is ready for use.



POSITION READOUT PANEL—The readout station has a six-digit readout for each axis and a six-digit manual data readout. It can be wall or floor mounted.



MAIN CONTROL ENCLOSURE—This unit houses the set-up panel, tape punch, solid state logic circuitry, test panel, power supply, and various support elements.

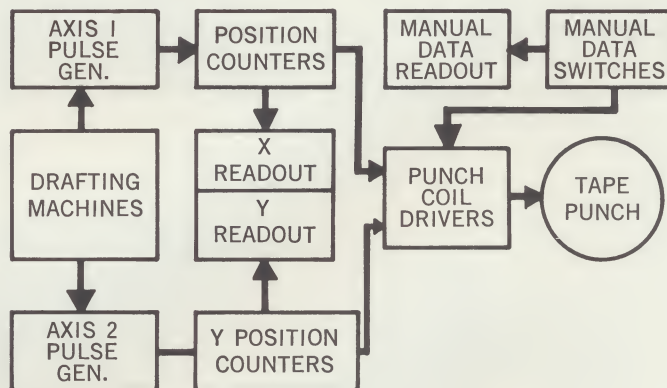


Printed circuit board . . . typical of parts that can be programmed by Autoprogrammer System.

AUTOPROGRAMMER SYSTEM SPECIFICATIONS

- Standard table size 48" x 48". Larger table available as an option.
- Scale ratios of $\frac{1}{4}$ to 1, $\frac{1}{2}$ to 1, 2 to 1, and 4 to 1 are available by selector switch setting.
- Round off feature is included to encode dimension to nearest 0.1 inch when desired.
- Equipment operates from 120 volts, 60 cycles, single phase.
- Ten amp circuit breaker is built in.
- A portable operator's console (12" x 9" x 7") is provided so that it may be moved to suit the operator's convenience.
- A position readout panel is provided containing three projection-type readouts. Two are for the table co-ordinates and the third is to display the auxiliary function words which are encoded manually.

MARK CENTURY AUTOPROGRAMMER



For ordering assistance or for more information on the Mark Century Autoprogrammer systems, contact your General Electric Sales Office, or Machinery Automation Sales, Specialty Control Dept., Waynesboro, Virginia.

Progress Is Our Most Important Product

GENERAL  ELECTRIC

SPECIALTY CONTROL DEPT., WAYNESBORO, VIRGINIA



Mark Century*

NUMERICAL CONTROL

OPTIONAL EQUIPMENT DATA SHEET

PHOTOELECTRIC TAPE READER

for contouring control

DESCRIPTION

For contouring operations requiring rapid tape reading rates, Mark Century contouring control systems can be equipped with a photoelectric tape reader. Featuring solid-state photo-diodes and eight-inch servo-driven reels, the reader will read at a nominal rate of 400 characters per second, and rewind at about 1000 characters per second.

Start and stop command signals to the tape reader are generated by the control. Photo-amplifiers for the tape tracks are internal to the reader. The reader accepts the standard logic level signals as used in Mark Century control.

In "read" condition, the tape is advanced by friction contact with a capstan

connected directly to the armature of a motor. Command signals from the control are synchronized with the sprocket hole such that the reader and control are always in synchronism.

When a start command is received, transistorized control circuits apply a current pulse to the armature to accelerate it and the tape. When a stop command is received, auxiliary circuits generate a reverse current pulse to rapidly decelerate the armature, stopping the tape.

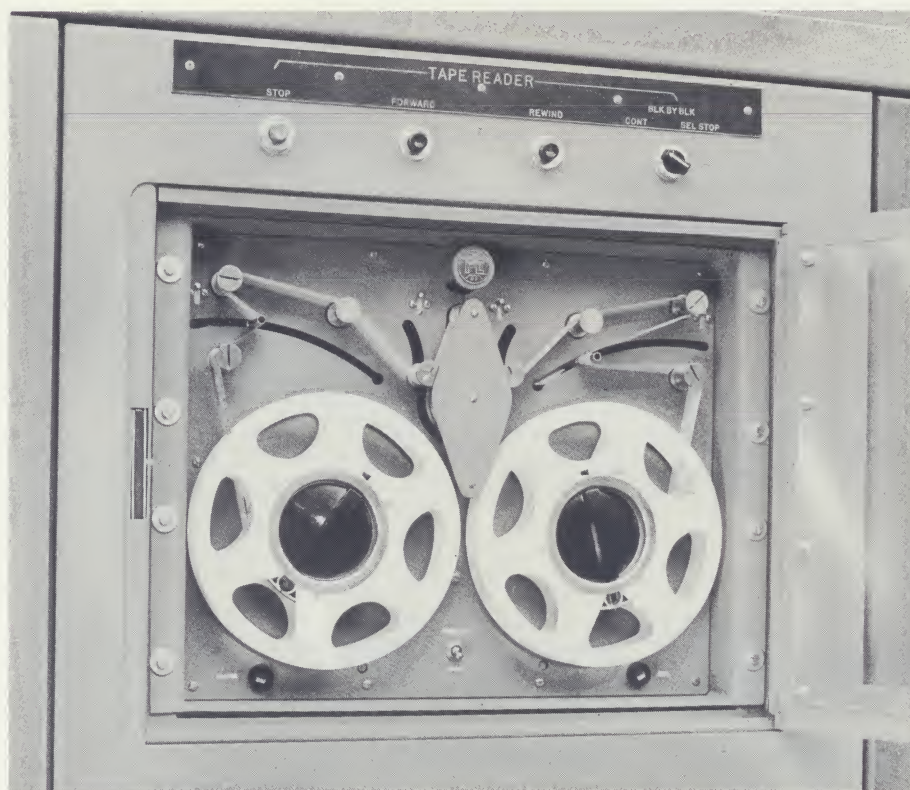
Each of the eight-inch reels is driven by a motor. In operation, the reels wind-on and wind-off tape as demanded by the capstan. A loop of tape is maintained on either side of the capstan by tape storage arms. Magnetic vanes attached to each

arm govern the application of power to the reel motors to supply or take up tape as necessary.

In rewind, both reels are first powered by a low voltage to increase tape tension and remove the storage loops. The tape tension lifts the pressure rollers away from the capstan. When the roller arms approach the limit of their travel, two snap-action switches are actuated, applying full power to the supply reel and removing power from the take-up reel.

The photo-diode amplifier board is located in the tape reader. Each amplifier receives a signal from its associated photo-diode located in the read head, and shapes it for use by the control. An input potentiometer can be used to adjust pulse width and rise time. Little or no adjustment should be necessary, as adjustment is made at the factory before shipment.

Fig. 1. Photoelectric tape reader



SPECIFICATIONS

Reading Speed—Nominal 400 characters per second when reading forward in slewing mode.

Rewind—Nominal 1000 characters per second. The system will recognize only the "stop character," but due to the high tape speed, the tape will not stop with the "stop character" over the reading head.

Tape—The reader will accommodate 8-channel paper, paper-Mylar† or aluminum Mylar punched tape. Light intensity and track amplifiers are adjusted at the factory for pink paper tape.

Reels—Two reels are driven by motors in accordance with the demands of the capstan. Reel capacities for various tapes are: Commercial paper, 0.0039 in. chuck, 650 ft; computer paper/paper Mylar, 0.0046 in. chuck, 550 ft; aluminized Mylar, 0.0025 in. chuck, 1000 ft.

"No-tape" Protection—With no tape in the read head, a "no-tape" signal is generated by the control to stop the reader.

* Trade-mark of General Electric Co.

† Reg. Trade-mark of E. I. DuPont de Nemours

OPERATING THE PHOTOELECTRIC READER

OPERATING MODES

The photoelectric tape reader can be operated in either the "Manual" or "Automatic" mode of control operation (determined by the mode selector switch on the control panel). In the "Semi-automatic" mode, tape reader power is off.

In "Manual," the reader is controlled by the operator with pushbuttons.

In "Automatic," the reader is controlled by signals from the Mark Century control.

MANUAL MODE

The reader is operated in both the forward and reverse (rewind) directions by pushbutton control.

Forward

When operated in the forward direction, the tape reader runs at normal reading speed in one of three modes of operation selected by a selector switch (See Fig. 1):

- Block-by-Block
- Continuous
- Selective Stop

Block-by-Block

This mode of operation is used to get to a specific block of tape information. The block being read is displayed by the sequence number display on the control panel. Parity Check, which shall have been previously reset with the "manual reset" pushbutton, is not effective until after the first "end of block" character (T8) is read. The reader will stop on all

subsequent "end of block" characters; operation must be restarted with the forward pushbutton.

In "block-by-block" operation, the "end of tape code" (m30) and "stop character" (T1, T2, T4) are not effective and will not stop the reader. Only the sequence number (letter N and accompanying digits) will be acted upon by the control.

Continuous

The "continuous" mode of operation is used to get to a particular section of the tape at a rapid rate. It is not intended as a means of getting to a specific block of tape information. When a particular section of tape is in the area of the reading head, the "block-by-block" mode can be used to locate the particular block of information desired.

Reader operation is initiated by pushing the "wind forward" button, and continues until the "rewind stop" button is depressed. During operation, every letter on the tape is recognized but only the sequence numbers (letter N and accompanying digits) are acted upon by the control. Though the "units" digits may not be readable on the sequence number display due to the speed of the tape, the "tens" digit will provide the operator satisfactory visual readout of the section of tape desired.

Selective Stop

The "selective stop" mode of operation is used to get to a particular part program when more than one part program is on a given tape. It is necessary that a "stop

character" be punched in the tape between each of the part programs.

If a tape has a number of part programs and each part program is preceded by a "stop character," any part program can be selected by pushing the "wind forward" button each time the reader stops. The tape can thus be advanced until the part program desired is brought into the immediate vicinity of the reading head. The operator must know how many programs must go through the reader to get to the program desired.

Rewind

When operating in "rewind" (actuated by "rewind" button), the feed reel (#2, Fig. 2) is motorized to pull the tape from the take-up reel to the rewind reel. The tape will continue to rewind until either the "rewind stop" button is pushed or a "stop character" (T1, T2, T4) is read by the reader.

During rewind, parity check is not effective. The "stop character" is the only tape information that will be read and acted on by the control. Because of the tape speed and method of driving the tape reel, the reader will not stop on the "stop character," but will over-run about six inches.

AUTOMATIC MODE

The tape reader can be initiated to run only in the forward direction by the operator when the control is in the "automatic" mode. The "wind forward," "rewind" and "rewind-stop" buttons are ineffective.

Reader operation is initiated with the "cycle-start" button on the operator's control panel. Parity Check shall have been previously reset by "manual reset," or by an "end of program" (m02), or "end of tape" code having been read.

Parity check will be set when the first "end of block" (T8) is read, thus, arming the "reading error" circuitry. A subsequent reading error will stop the tape reader, and cause the machine to dwell at the position established by the last command. After the reading error has been corrected, "reading error" circuitry is automatically reset when "cycle-start" button is depressed to restart reader operation.

Reading an "end of tape" code (m30) will cause the tape reader to rewind the tape. Rewind will continue until a "stop character" (T1, T2, T4) is read.

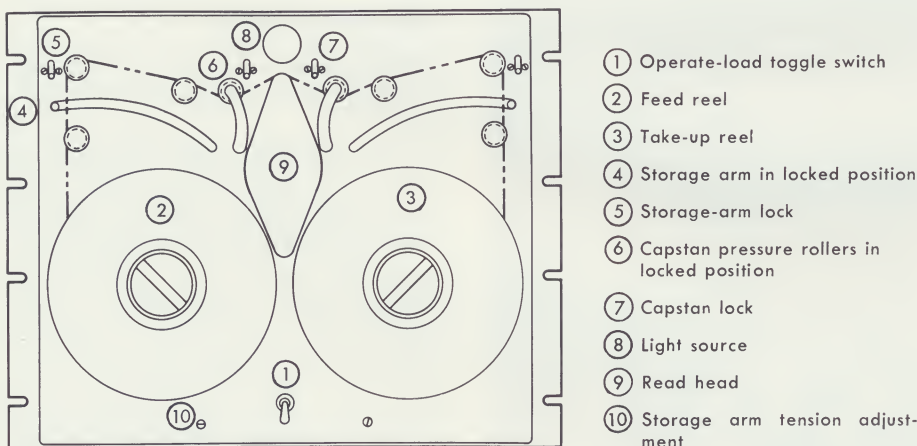


Fig. 2

GENERAL  ELECTRIC

SPECIALTY CONTROL DEPT., WAYNESBORO, VA.



Mark Century^{*}

NUMERICAL CONTROL

OPTIONAL EQUIPMENT DATA SHEET

HIGH-SPEED MECHANICAL TAPE READER

for contouring or positioning control systems

DESCRIPTION

The Tally mechanical tape reader, available with either contouring or positioning control systems, reads at a rate of 62.5 characters per second in the forward direction, and rewinds at the same rate. The rewinding rate with the tape removed from the reading head is about 150 feet per minute.

The reader is supplied with bi-directional tape reeling equipment mounted on either side of the read head. The tape reels are rotated by a differential gear and brake mechanism actuated by tape tension arms. Both mechanisms are driven by belts from a capstan drive assembly. Since the units are bi-directional, either reel can be the take-up or supply side depending upon direction of tape movement.

No tape threading change is required when reversing the direction of tape movement. All slack on the supply reel is taken up through the action of the tension arms. Six-inch diameter NARTB reels are removable from the NARTB shafts by a simple snap arrangement for quick loading and unloading.

Perforations in the tape are sensed by five-point star wheels. See Figure 2 (a). Spring pressure applied to the star wheel lever by each pair of movable contacts holds the star wheel lightly against the tape.

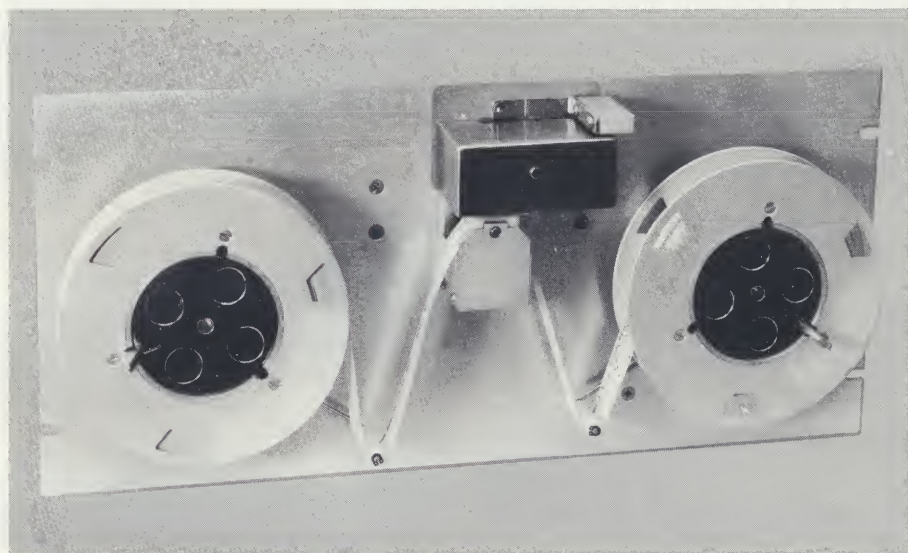


Figure 1. Tally mechanical tape reader

When a no-hole condition is sensed, the star wheel rides the tape on two of its points, and the movable contact is switched to the upper, normally closed (N/C) position. When a hole is sensed (with the tape moving in either direction), one of the star wheel points drops through the hole, as shown in Figure 2 (b), and the

movable contact is switched downward to the normally open (N/O) position. Consequently, an electric pulse delivered to the movable contact wire (common) will be conducted to the N/C terminal if a no-hole is sensed, or to the N/O terminal if a hole is sensed.

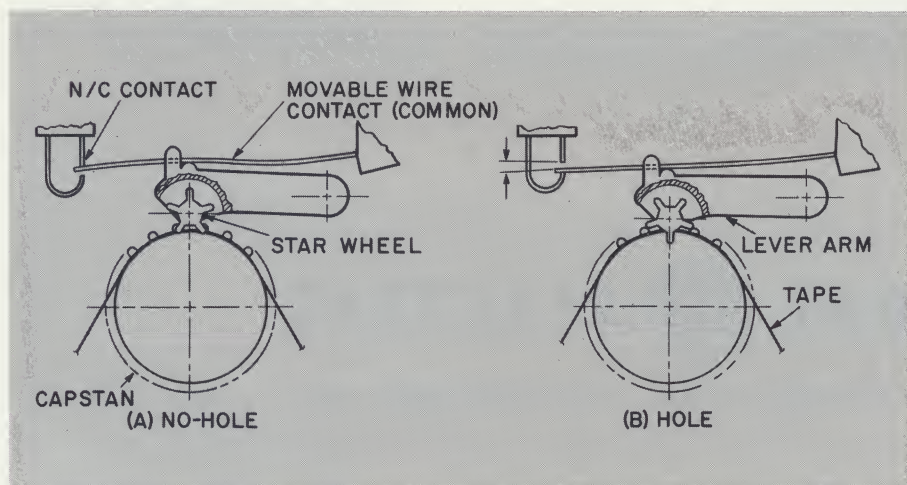


Figure 2. Starwheels reading perforated tape

SPECIFICATIONS

Reading speed—62.5 characters per second when reading forward.

Rewind—62.5 characters per second with tape in the reader. The system will recognize only the "stop character" which initiates tape stop.

Tape—Reader will accommodate 1-inch-wide, 8-channel paper, paper-Mylar† or aluminum-Mylar, or Mylar perforated tape.

Reels—The reels are 6 inches in diameter. Reel capacities for various tapes are

Commercial paper	210 ft.
Computer paper/paper Mylar	210 ft.
Aluminized Mylar	240 ft.
Mylar	335 ft.

^{*} Trade-mark of General Electric Co.

[†] Reg. trade-mark of E. I. DuPont de Nemours

OPERATING THE TALLY MECHANICAL READER

OPERATING MODES

The Tally mechanical tape reader can be operated in either the "Manual" or "Automatic" mode of control operation (determined by the mode selector switch on the control panel). In the "Semi-automatic" mode, tape reader power is off.

In "Manual," the reader is controlled by the operator with pushbuttons.

In "Automatic," the reader is controlled by signals from the Mark Century control.

MANUAL MODE

The reader is operated in both the forward and reverse (rewind) directions by pushbutton control.

Forward

When operated in the forward direction, the tape reader runs at normal reading speed in one of three modes of operation selected by a selector switch (See Figure 3):

- Block-by-Block
- Continuous
- Selective Stop

Block-by-Block

This mode of operation is used to get to a specific block of tape information. The block being read is displayed by the sequence number display on the control panel. Parity Check, which shall have been previously reset with the "manual reset" pushbutton, is not effective until after the first "end of block" character (T8) is read. The reader will stop on all subsequent "end of block" characters; operation must be restarted with the forward pushbutton.

In "block-by-block" operation, the "end of tape code" (m30) and "stop character" (T1, T2, T4) are not effective and will not stop the reader. Only the sequence number (letter N and accompanying digits) will be acted upon by the control.

Continuous

The "continuous" mode of operation is used to get to a particular section of the tape at a rapid rate. It is not intended as



Figure 3. Tape reader controls

a means of getting to a specific block of tape information. When a particular section of tape is in the area of the reading head, the "block-by-block" mode can be used to locate the particular block of information desired.

Reader operation is initiated by pushing the "wind forward" button, and continues until the "rewind stop" button is depressed. During operation, every letter on the tape is recognized but only the sequence numbers (letter N and accompanying digits) are acted upon by the control. Though the "units" digits may not be readable on the sequence number display due to the speed of the tape, the "tens" digit will provide the operator satisfactory visual readout of the section of tape desired.

Selective Stop

The "selective stop" mode of operation is used to get to a particular part program when more than one part program is on a given tape. It is necessary that a "stop character" be punched in the tape between each of the part programs.

If a tape has a number of part programs and each part program is preceded by a "stop character," any part program can be selected by pushing the "wind forward" button each time the reader stops. The tape can thus be advanced until the part program desired is brought into the immediate vicinity of the reading head. The operator must know how many programs must go through the reader to get to the program desired.

Rewind

When operating in "rewind" (actuated by "rewind" button), the feed reel (left, Fig. 1) is motorized to pull the tape from

the take-up reel to the rewind reel. The tape will continue to rewind until either the "rewind stop" button is pushed or a "stop character" (T1, T2, T4) is read by the reader.

During rewind, parity check is not effective. The "stop character" is the only tape information that will be read and acted on by the control. Because of the tape speed and method of driving the tape reel, the reader will not stop on the "stop character," but will over-run about six inches.

AUTOMATIC MODE

The tape reader can be initiated to run only in the forward direction by the operator when the control is in the "automatic" mode. The "wind forward," "rewind" and "rewind-stop" buttons are ineffective.

Reader operation is initiated with the "cycle-start" button on the operator's control panel. Parity Check shall have been previously reset by "manual reset" or by an "end of program" (m02), or "end of tape" code having been read.

Parity check will be set when the first "end of block" (T8) is read, thus, arming the "reading error" circuitry. A subsequent reading error will stop the tape reader, and cause the machine to dwell at the position established by the last command. After the reading error has been corrected, "reading error" circuitry is automatically reset when "cycle-start" button is depressed to restart reader operation.

Reading an "end of tape" code (m30) will cause the tape reader to rewind the tape. Rewind will continue until a "stop character" (T1, T2, T4) is read.

GENERAL  ELECTRIC
SPECIALTY CONTROL DEPT., WAYNESBORO, VA.



Mark Century*

NUMERICAL CONTROL

OPTIONAL EQUIPMENT DATA SHEET

ACCUPIN* POSITION MEASURING SYSTEM

FUNCTION

The Accupin position measuring system was developed by General Electric specifically for use with numerically controlled machines. It provides a highly accurate measurement of machine member position, and is particularly useful where machine lengths prohibit the use of accurate lead-screws, or where high cutting speed is required.

The low-cost Accupin unit can be applied to milling machines, boring machines, and multi-purpose drill-mill and boring machines to measure linear or angular position. Applicable to all positioning functions, the Accupin system operates without mechanical linkages (such as gears, slip rings and brushes) or optical transducer stages. It works with virtually any machine-tool drive (supplied by General Electric Co.), eliminating errors associated with machine gearing.

DESCRIPTION

The Accupin linear positioning scale

sections look like a comb. Scale sections come in 6- and 10-inch lengths, which are connected together for the total length of motion required. The "teeth" are steel pins of precise diameter, accurately positioned on 0.1-inch centers. (This spacing is compatible with decimal-number commands and measurement in inches.)

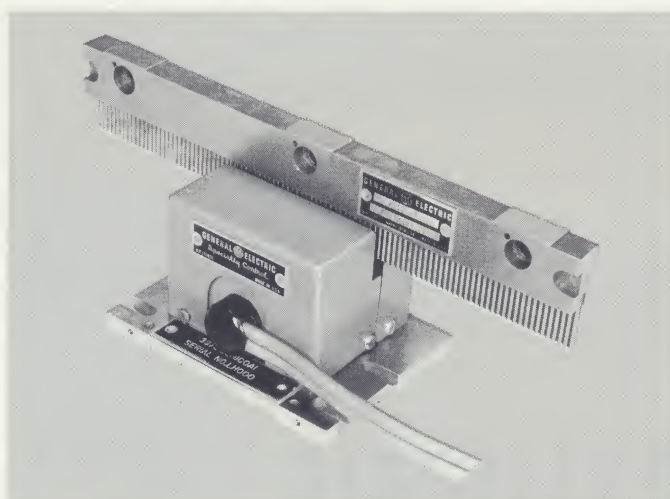
In the Accupin rotary positioning system, the pins are mounted in a circle like a "wheel of fortune." There are 360 pins located precisely on degree points around a 36-inch (circumference) circle. The circumferential arc distance is essentially 0.1-inch so that the same pin size and core laminations are used on this unit as in the linear device. The reading heads are assembled with the pole faces shaped in an arc. Output of these heads is identical to the linear unit and can be used with the same control systems.

OPERATING PRINCIPLE

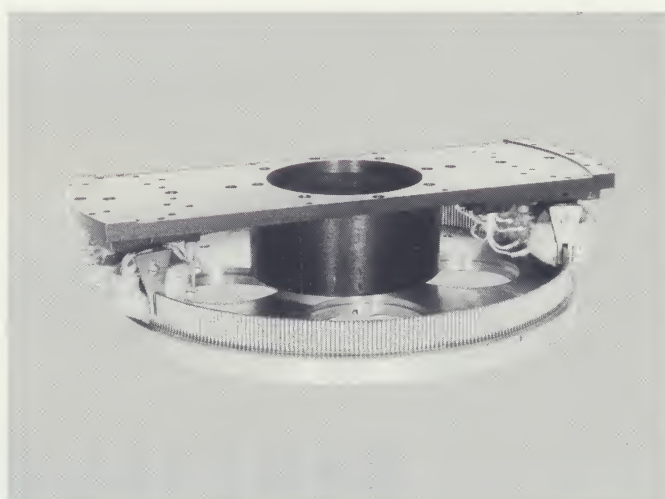
Operating on the magnetic induction bridge principle, the Accupin sys-

tem is relatively simple in theory and construction. For position measuring, the pins pass through the air gaps of "C"-shaped magnetic core in the sensing heads to produce two amplitude-varying a-c voltages. These voltages are combined to produce a phase shifted, constant amplitude signal that shifts phase linearly as the scale is moved through sensing heads. Measurement is obtained because this voltage phase changes in a precise manner for each 0.1-inch advance of the pin scale with respect to the sensing head.

The magnetic inductive bridge has been used as the basic sensing circuit of the General Electric tracing system and in many other position comparators. Historically, this element has been proved capable of infinite resolution, and is a stable and reliable measuring system. The pin scale and sensing head arrangement results in a device that is directly attached to the worktable, and has no mechanical contact wear points or backlash.



The Accupin linear feedback device is optional with Mark Century control. It provides position measurement without the use of lead-screw or instrument-type gearing.



Rotational measurement is done with 360 pins accurately spaced on one degree centers. Output is identical to the linear unit, and can be used with the same control systems.

* Reg. Trade-mark of General Electric Co.

RUGGED CONSTRUCTION

Head and pin scales are constructed for industrial applications. The scale consists of nickel steel pins ground to ± 0.000030 -inch diameter tolerance, and set in a deep groove in the non-magnetic bar. The pins are all smaller than 0.1-inch so that a small space is present between each pin.

The ruggedly built sensing head has no moving parts. The base is a steel plate with a flat mounting surface on the under side.

Materials have been used to closely approximate the normal expansion of

the machine-tool members. Normal temperature changes in a precision machine room will not affect the accuracy of machining steel parts that have the same thermal expansion coefficient as the machine.

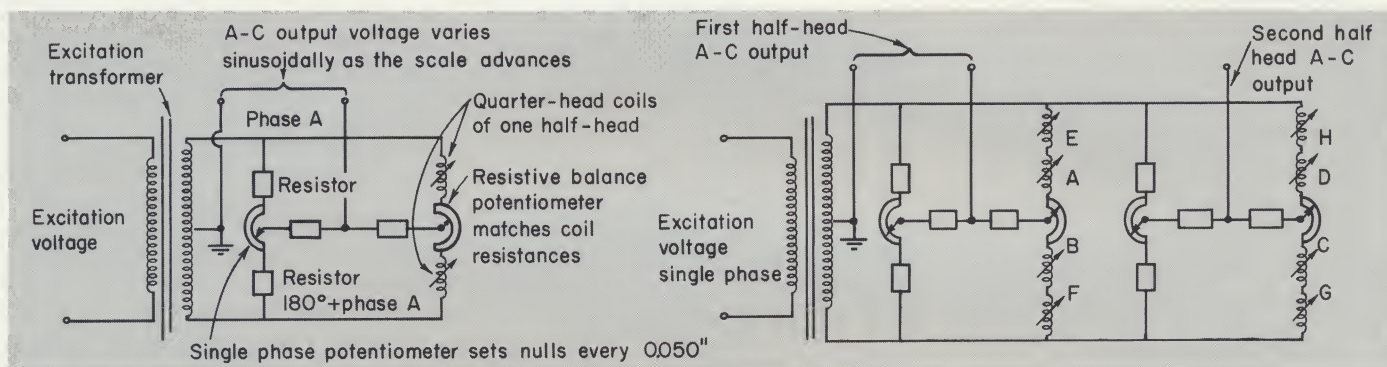
RESOLUTION

Each half-head output is fed to a summing circuit; each half-head is excited with a different phase a-c voltage. The excitation phases are 90 electrical degrees apart. The sum of these two electrical signals produces a constant a-c amplitude signal which has a spe-

cific phase associated with any position of the pin scale in the sensing head. The Mark Century command resolution is 0.0001 inch, but the signal resolution is less than 10 millionths of an inch.

The correct set of pins is established by a coarse selection system, after which the control automatically transfers to the high-accuracy system—about 0.005 to 0.008-inch before the correct stop point.

The output of the multiphase sensor circuits is like a two-phase excited resolver that is mechanically rotated one revolution per 0.1-inch of linear motion.



Inductance-bridge circuit is formed by two inductive heads and a center-tapped transformer. Output voltage of this bridge is a sinusoidally varying a-c voltage that completes a cycle each 0.1-inch to provide precise measurement.

GENERAL ELECTRIC

SPECIALTY CONTROL DEPT., WAYNESBORO, VA.

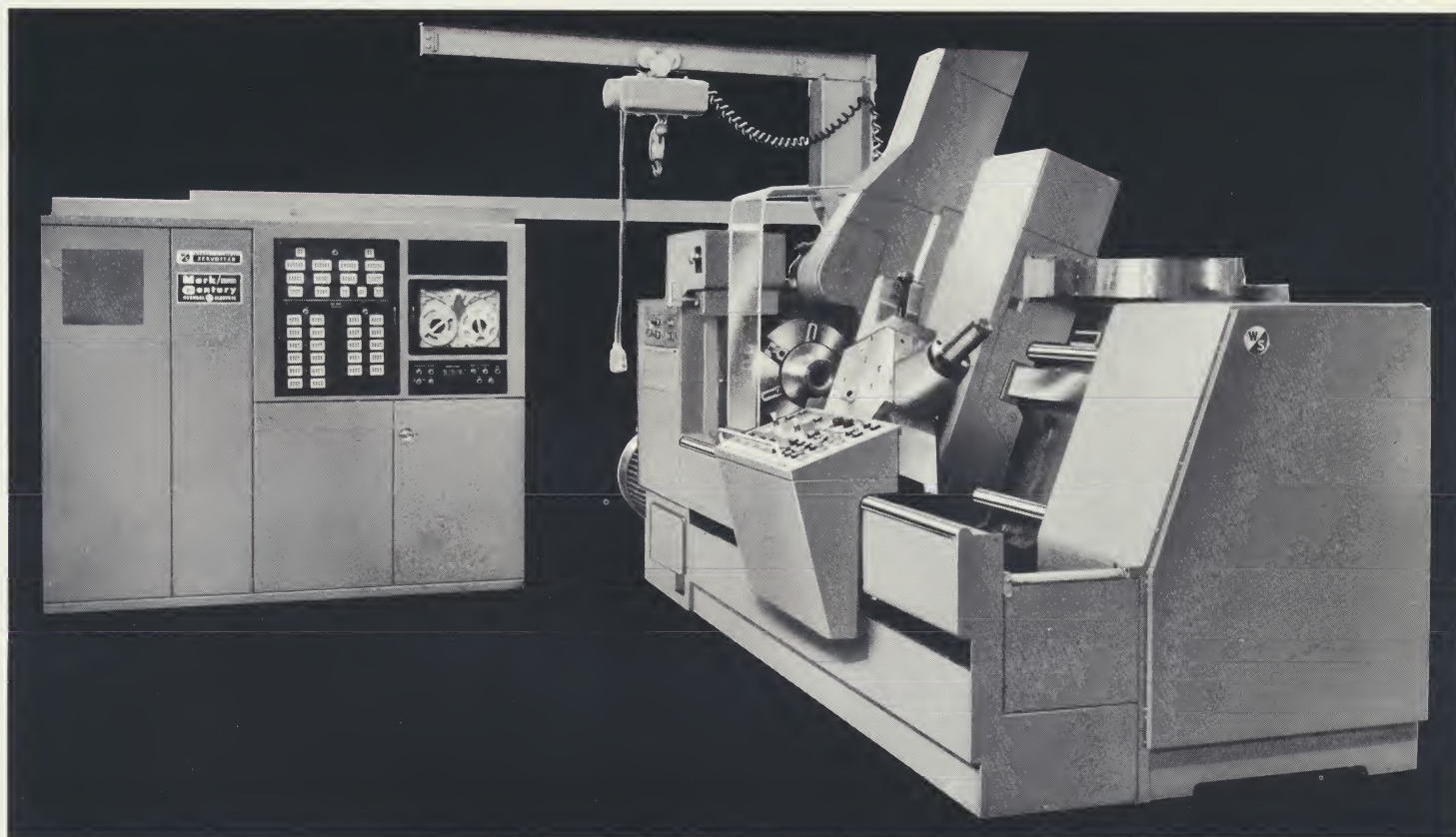
Another example of modernized machining

Warner & Swasey SC-25 SERVOFEED 4-Axis Turret Lathe

with

General Electric Mark Century* Numerical Control

* Trade-mark of General Electric Co.



Tape-controlled twin 2-axis turret lathe combines cuts, shortens cycle time

FEATURES

- Mark Century solid state control and Warner & Swasey Servodrives for optimum reliability and accuracy
- Simultaneous tape control of two independent tool slides
- Unique slant-bed construction for maximum rigidity and accessibility
- Rugged 32-speed turret lathe headstock has 60/30 hp motor

DESCRIPTION

The Warner & Swasey SC-25 turret lathe with General Electric Mark Century numerical control shortens your job cycle time by simultaneously or independently cutting with two turrets.

Using a single tape and a single photoelectric tape reader, the Mark Century control provides separate two-axis directional control for each slide. Both the six-station side turret and

pentagon end turret have full capability for turning, boring, facing, contouring, taper cutting, and threading.

The SC-25 machine is designed for heavy duty production. It is equipped with a rugged gear scroll chuck which can grip a wide range of parts . . . with a minimum of jaw changes. And the chuck's open bore permits gripping long castings or forgings, as well as bars. A slanting "A" frame bed — with widely spaced ways — provides a big swing. Yet, the operator can remain close to the spindle for easy workpiece loading and gaging.

A heavy-duty hydraulically-shifting head-stock and a 60 horsepower two-speed motor provide 32 unduplicated speeds for efficient metal removal with even combined cuts. Variable speed drives are also available.

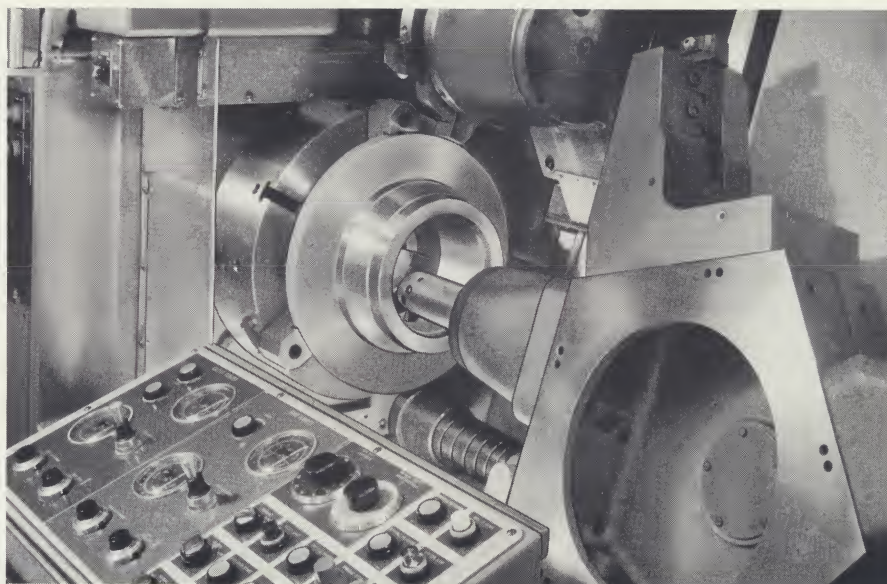
Both tool slides are moved by precision ball screw feed shafts driven by Warner & Swasey high performance electric servodrives. Both turrets feature curvic coupling mountings for greater index accuracy.

TAPE CONTROL FUNCTIONS

G-E Mark Century numerical control provides fully automatic functioning of the lathe. Feed rate, spindle speed, slide movement, turret positions, and auxiliary functions (coolant on-off and optional cycle stops) are all numerically controlled. Circular interpolation provides a simple means of programming radii up to 9.9999 inches. A pair of tool offsets — furnished for each station — allows the operator to adjust quickly for cutter wear and tooling variations.

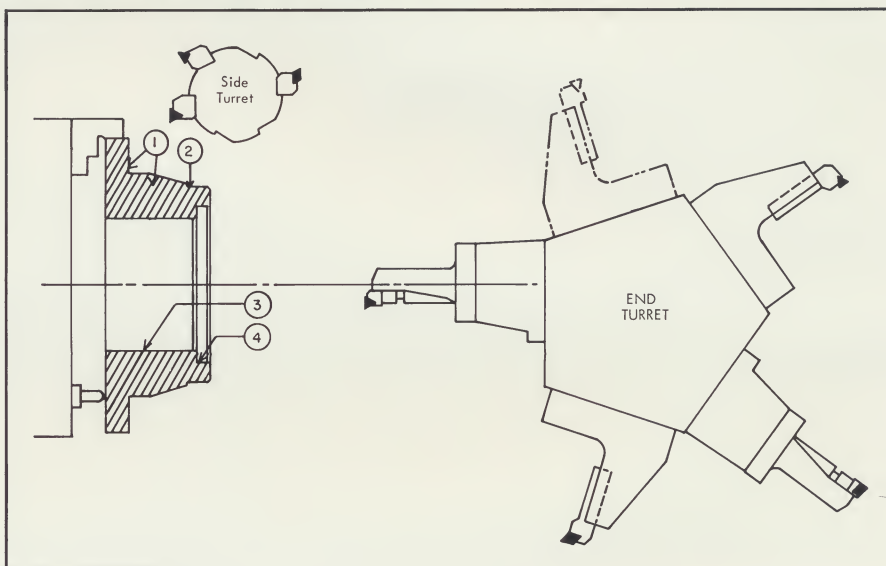
Programming can be done either manually or by computer.

Complete hand controls are provided on the SC-25's movable control console. The console can be positioned anywhere along the front rail permitting the operator to clearly observe both the workpiece and cutters as he maneuvers the slides.



Here's an example of two-slide versatility...

Combined cutting with the two independent tool slides assures minimum cycle time on the 18-inch flange shown in this setup. For example, the side turret is programmed to rough turn and contour surfaces (1) and (2), while the end turret rough bores (3) and (4).



SPECIFICATIONS

Swing	
Maximum	25"
Over Carriage	21"
Chuck Diameter	24"
Pentagon End Turret	
Maximum longitudinal travel.....	51"
Maximum cross travel.....	16"

Side Turret (6 position)	
Maximum longitudinal travel.....	51"
Maximum cross travel.....	14"
Feeds	
All longitudinal and cross feeds infinitely variable from 0.05 to 18 inches per minute	
Spindle Speeds	
32 unduplicated speeds.....12 to 851 rpm	



For more information on Warner & Swasey SERVO-FEED turret lathes, contact your Warner & Swasey representative or write to The Warner & Swasey Company, 5701 Carnegie Avenue, Cleveland, Ohio 44103.

Warner & Swasey

Mark 100 Century

For descriptive information on General Electric numerical control systems, write for bulletin GEA-7590, Distribution Services, General Electric Co., Schenectady, N. Y. 12305.

GENERAL ELECTRIC

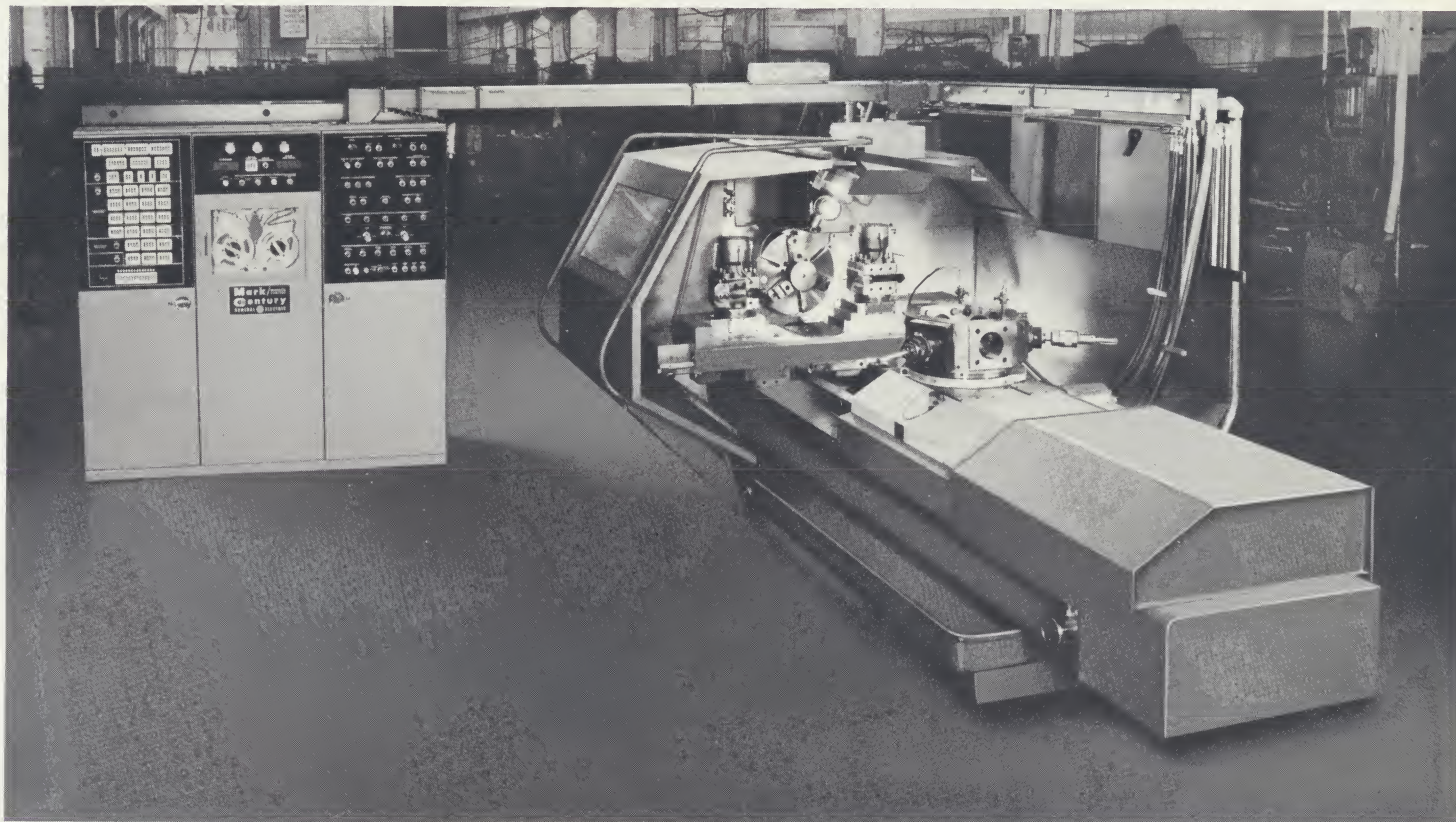
JONES & LAMSON

MODEL 4518-NCTL TURRET LATHE

with

General Electric Mark Century* Numerical Control

* Trade-mark of General Electric Co.



... for a tape-controlled continuous-path contour-turning three-axis lathe

FEATURES

- 2-piece construction for greatest accuracy and for subsequent re-alignment.
- 24-speed headstock for powerful, silent, vibration-free transmission.
- Saddle and turret — with Geneva motion — provides rapid indexing.
- Bridge-type carriage for greater rigidity.
- Servo drives use precision ball-nut lead screws.
- Automatic side-loading bar feed available.

DESCRIPTION

The Jones & Lamson Model 4518-NCTL three-axis turret lathe with General Electric Mark Century numerical control is tailored to accept added functions related to turret lathe operations.

The carriage and cross slide respond to linear and circular interpolation of

programmed information for continuous-path turning. At the same time, the saddle responds to end point positions for the third axis of motion.

By selection of 14 tool location positions, many operations related to turned parts can be done in a minimum of set-up time . . . through preset tooling. Twenty-two tool-point offsets are provided at plus or minus 0.0999 inch. Tool offsets are available: two for each tool on the carriage and cross slide (X and Y), and one for each tool on the hex turret (W).

Two precision square turrets are accurately positioned for tool end point location. Each face of the hexagon turret mounted on the saddle is precisely machined for end-point positioning of end working tools with the full range of plus or minus offset.

Feed-rate overrides are provided for each of the 14 tool positions. They range from 100 percent to 10 percent

of the programmed feedrate for chip control and finish requirements.

The G-E Mark Century control system has full capabilities for manual data input and manual operation required for turning operations. Turret selection, spindle operation, coolant on or off, tool operation, collet or power chuck operation, motions for each axis, and safety modes of operation are easily accessible to the operator.

A safety walk-around hand control is provided for the operator to observe the machine operation from points of best advantage, so he can stop all motions and spindle rotation if needed.

In addition, General Electric has developed the GECENT post-processor to use the data produced by the APT processor to prepare operating tapes for many machines using Mark Century control. Other programs and post-processors are also available.

NUMERICAL CONTROL FEATURES

- Full circular interpolation permits programming arcs up to 90 degrees with a single block of input data.
- A block of ten auxiliary functions — such as on-off controls, coolant flow and clutch circuits — can be programmed on the tape.
- Up to 24 different spindle speeds can be programmed for maximum flexibility.
- Maximum of 10 different tools can be programmed.
- Twenty-two tool zero offsets provide the operator with a precise method of setting the cutting edge of the tool.

SPECIFICATIONS

Swing.....18" max. over cross slide
30" max. over carriage way guides

Workpiece capacity

Bar

Round1" to 4½"
Hexagonal1" to 3⅞"
Square1" to 3⅞"

Chuck

Max. dia. over cross slide.....18"

Effective workpiece capacity

Spread between code points on square
turrets20"
Max. turning dia. with standard tool in either
square turret18"
Max. length from flange of spindle nose to face
of hex. turret67"

Distance across faces of hex. turret.....18"
Dia. of tool positioning hole on hex. turret....4.500

Positioning accuracy

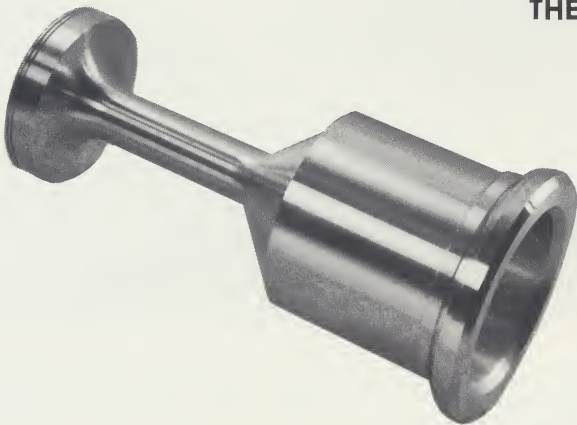
Saddle0.002"
Carriage0.002"
Cross slide0.001"

Positioning precision repeatability

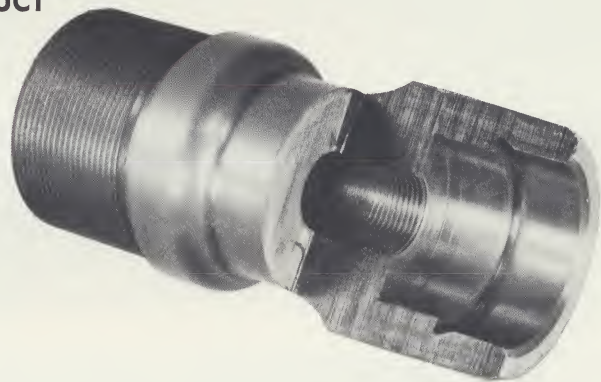
Saddle0.001"
Carriage0.0005"
Cross Slide0.0005"
Rapid traverse400"/minute
Feed rates.....0.1 to 80"/min.
Speed range.....50 to 1
Number of speeds.....24 forward
12 reverse

Spindles.....11" B-1, 4½" dia. bar, 24-1200
Drive40 hp

THE PRODUCT



Control valve: Made from an aluminum billet completely turned inside and out with all dimensions and finish requirements held. The part was completed in a cycle time of 19 minutes, removing 38 pounds of aluminum in chips. Previous time for making this part was one piece per 8-hour shift.



Steel coupling: This part was machined complete including cut-off in 9½ minutes on the N.C. Turret Lathe. On a standard manual Turret Lathe equipped with tracing attachment and threading attachment, the part took 18 minutes, floor to floor.

The change over from the aluminum valve to the steel coupling (including the machining of one coupling) is less than a half-hour.



For detailed information on the Jones & Lamson turret lathe, write to Jones & Lamson, Springfield, Vermont.

JONES & LAMSON

DIV. OF WATERBURY FARREL - A **textron** COMPANY

SPRINGFIELD, VERMONT, U. S. A.

Mark Century

For descriptive information on G-E Mark Century numerical control systems, write for Bulletin GEA-7590, Distribution Services, General Electric Co., Schenectady, New York.

GENERAL ELECTRIC

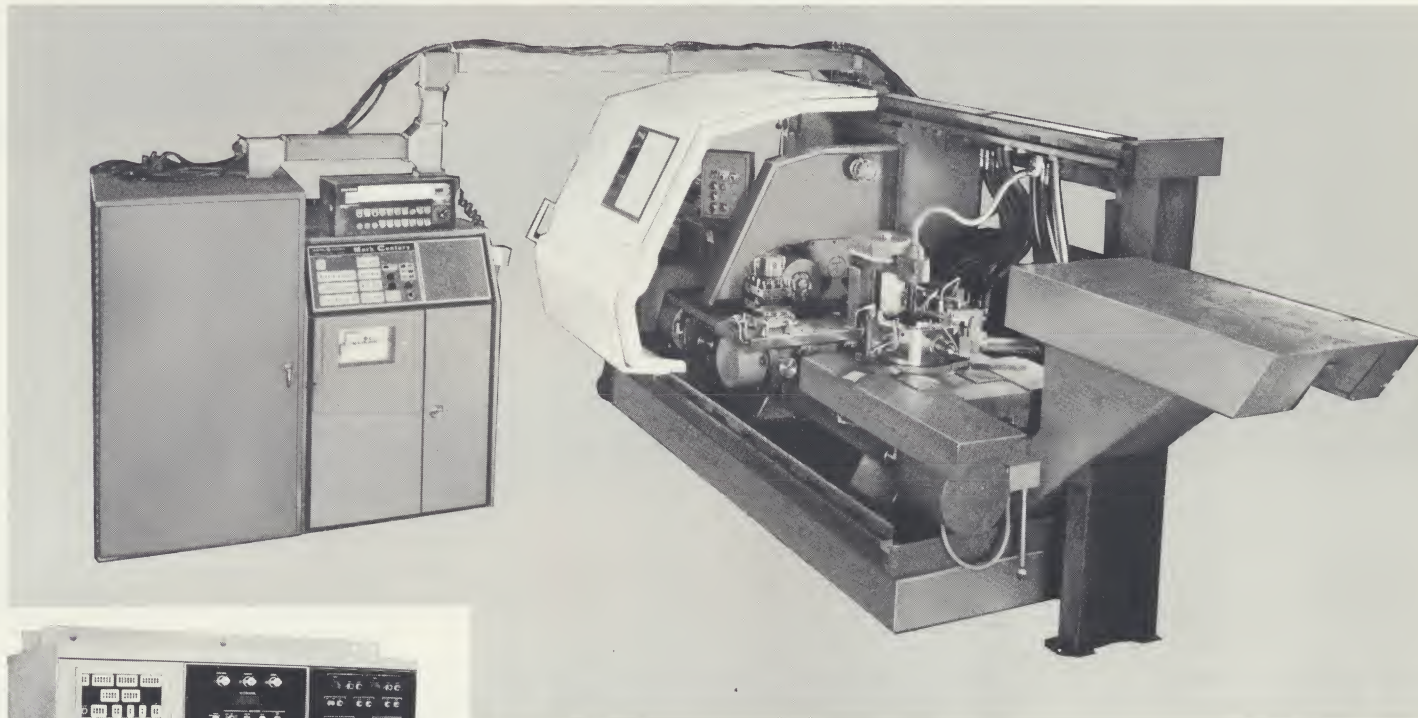


JONES & LAMSON MODEL 312-NCTL TURRET LATHE

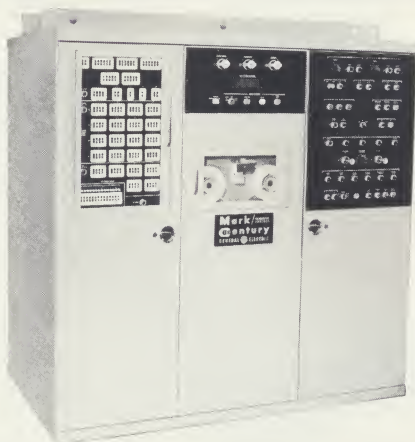
with

General Electric Mark Century* Numerical Control

* Trade-mark of General Electric Co.



Either the General Electric low cost Mark 100S numerical control (shown with machine) or this G-E Mark Century 103 control is available.



... for three-axis continuous-path contour-turning operations

FEATURES

- 2-piece construction for greatest accuracy and for subsequent re-alignment.
- 12-speed headstock for powerful, silent, vibration-free transmission.
- Saddle and turret — with Geneva motion — provides rapid indexing.
- Bridge-type carriage for greater rigidity.
- Servo drives use precision ball-nut lead screws.
- Automatic side-loading bar feed available.

DESCRIPTION

The Jones & Lamson Model 312-NCTL three-axis turret lathe with General Electric Mark Century numerical control is tailored to accept added functions related to turret lathe operations.

The carriage and cross slide respond to linear and circular interpolation of programmed information for continuous-path turning. The saddle responds to end point positions for the third axis of motion.

By selection of 14 tool location positions, many operations related to turned parts can be done in a minimum of set-up time . . . through preset tooling.

The machine is available with either G-E low-cost Mark 100S control or deluxe Mark Century 103 control. With the 100S unit, four pairs of tool-point offsets are provided at plus or minus 0.0099 inch. With the 103 unit, 22 offsets are provided at plus or minus 0.0999 inch.

For each tool on the carriage and cross slide, two offsets are available for each axis of motion (X and Y).

Two precision square turrets are accurately positioned for tool end point location. Each face of the hexagon turret mounted on the saddle is precisely machined for end-point positioning of end working tools with the full range of plus or minus offset.

With the Mark Century 103 control, feed-rate overrides are provided for each of the 14 tool positions. With the Mark 100S control, only one is provided. They range from 100 percent to 10 percent of the programmed feedrate for chip control and finish requirements.

The G-E Mark Century control system has full capability for manual data input and manual operation required for turning operations. Turret selection, spindle operation, coolant on or off, tool operation, collet or power chuck operation, motions for each axis, and safety modes of operation are easily accessible to the operator.

A safety walk-around hand control is provided for the operator to observe

the machine operation from points of best advantage, so he can stop all motions and spindle rotation if needed.

NUMERICAL CONTROL FEATURES

- Full circular interpolation permits programming arcs up to 90 degrees with a single block of input data.
- A block of ten auxiliary functions — such as on-off controls, coolant flow

and clutch circuits — can be programmed on the tape.

- Up to 24 different spindle speeds can be programmed for maximum flexibility.
- Maximum of 14 different tools can be programmed.
- Maximum of 22 tool zero offsets provide the operator with a precise method of setting the cutting edge of the tools.

SPECIFICATIONS

Swing.....12" max. over cross slide, 18" max. over carriage way guides

Workpiece capacity

Bar

Round1/2" to 3"
Hexagonal1/2" to 2 5/8"
Square1/2" to 1 1/8"

Chuck

Max. dia. over cross slide.....12"

Effective workpiece capacity

Spread between code points on square turrets.....15"
Max. turning dia. with standard tool in either square turret12 1/2"
Max. length from flange of spindle nose to face of hex. turret35 1/2"

Distance across faces of hex. turret.....16"
Dia. of tool positioning hole on hex. turret3.125" or 3.375" (depending upon tooling)

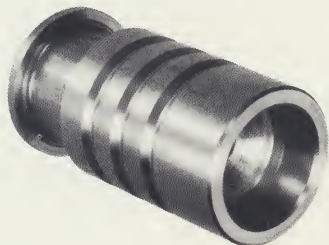
Positioning accuracy

Saddle0.002"
Carriage0.002"
Cross slide0.001"

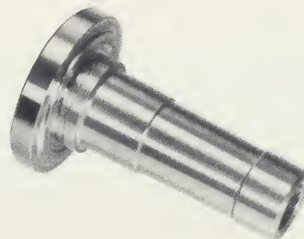
Positioning precision repeatability

Saddle, carriage, and cross slide.....0.001"
Rapid traverse.....200"/minute, all axes
Feed rates.....0.1 to 50"/min.
Speed range.....50 to 1
Number of speeds.....12 forward, 12 reverse
Spindles.....8" A-1, 3" dia. bar, 48-2000
Drive30 hp

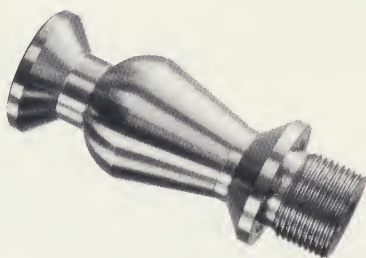
THE PRODUCT



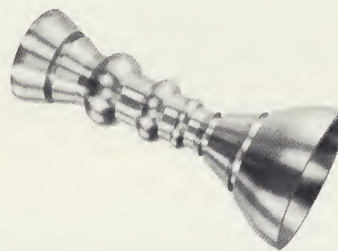
Connecting sleeve: Made of two-inch bar steel, this part was machined in only 5.6 minutes on the J&L Model 312-NCTL with G-E Mark Century n/c.



Manual shift handle: Only 5.30 minutes were needed to machine this part from a two-inch steel bar.



Test plug: This part — also made of two-inch bar steel, was machined in 4.5 minutes.



Aluminum test part: With the J&L 312-NCTL lathe and G-E n/c this part was machined from a four and a half inch aluminum bar in just 14 1/2 minutes. The end of the bar is cupped out with a hole drilled at the bottom.



For detailed information on the Jones & Lamson turret lathe, write to Jones & Lamson, Springfield, Vermont.

JONES & LAMSON

DIV. OF WATERBURY FARREL - A **Textron** COMPANY

SPRINGFIELD, VERMONT, U. S. A.

Mark Century

For descriptive information on G-E Mark Century numerical control systems, write for Bulletin GEA-7590, Distribution Services, General Electric Co., Schenectady, New York.

GENERAL  **ELECTRIC**

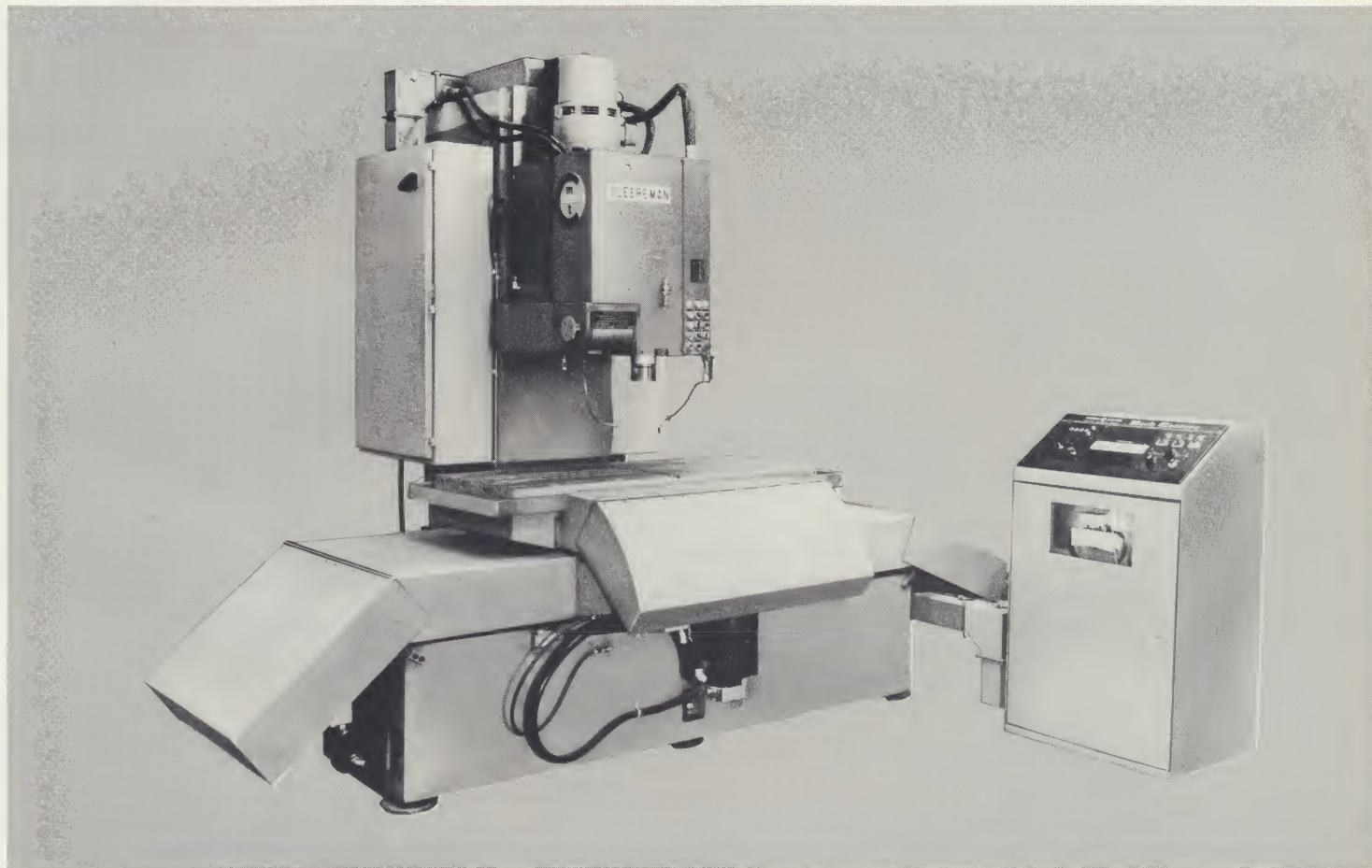
Another example of modernized machining

CLEEREMAN DRILLMASTER

with

General Electric Mark Century* Numerical Control

*Trade-mark of General Electric Co.



... for drilling, tapping, reaming and milling operations

FEATURES

- Large spindle and quill
- Power tool lock and release
- Operator convenience
- Power raise and lower to sliding head with automatic clamp
- Generous feed range
- Quick change boring and milling spindle
- Anti-friction ways
- 10" of spindle travel and 12" head travel
- Tape controlled speeds and feeds
- Full floating zero
- Reversing spindle
- Power feed dwell to spindle

DESCRIPTION

The CLEEREMAN Drillmaster with General Electric Mark Century numerical control, is a rugged, numerically controlled machine tool to perform drilling, tapping, boring and reaming operations. Milling is included as standard.

The machine is intended for numerical control and features automatic spindle cycle, tape controlled speeds and feeds, power raising and lowering of the sliding head with automatic clamp and an all-gear head. Manual data input can also be furnished. There are no belts or pulleys for either the speed transmission or spindle feed arrangement, thus providing more horsepower at the spindle and drastically reducing maintenance cost.

The clean lines of the Drillmaster suggest ease of operation for the operator. There are no levers or handwheels—even when the machine is ordered with manual data input. It is truly a tape controlled machine and reflects the latest in design for both machine and control.

The machine uses no hydraulics and is equipped with a separate compact G-E console for the control system. Heavy gauge sheet metal guards fully protect the ways and lead screws even

at extremes of table travel.

NUMERICAL CONTROL FEATURES

- **Absolute data input** — two axes controlled simultaneously with a maximum command of 99.9999 inches for each axis
- **Resolution** — minimum input dimension is 0.0001 inch
- **Zero offset**—makes it possible to locate the zero point of the control system at any point on the machine table
- **Backlash take-up**—a backlash take-up circuit for each motion provides for final positioning from the same direction regardless of the previous position
- **Straight-line milling** — truly proportional d-c servo drives permit milling along any machine axis
- **Rotary resolver feedback** — provides precise correspondence of command signal and machine-tool position

SPECIFICATIONS

Diameter of spindle at bearings.....	2"
Diameter of quill.....	37/8"
Spindle travel.....	10"
Head travel.....	12"
Distance spindle nose to table (min-max)....	4" to 26"
Number of spindle speeds.....	9
Speed range.....	100 to 2000 rpm or 150 to 3000 rpm
Number of spindle feeds.....	99
Range of feed rates.....	0.5 to 49.5 ipm
Motor, hp.....	5
Optional.....	5/21/2
Working surface of table:	
Model J-2.....	22" x 30"
Model J-3.....	22" x 54"

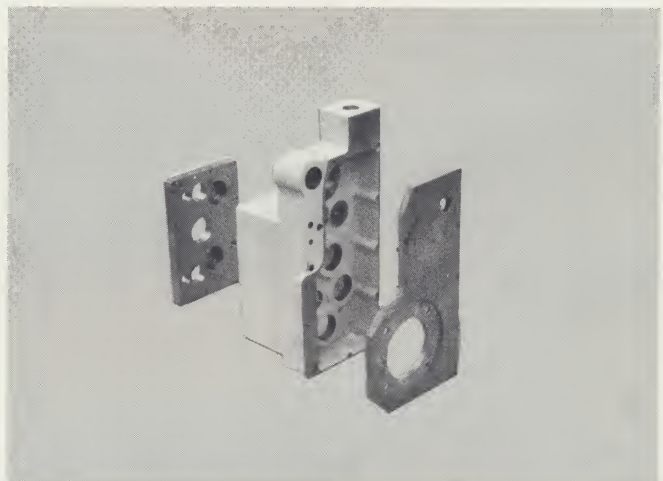
Travel—longitudinal "X" axis	
Model J-2.....	24"
Model J-3.....	48"
Travel—transverse "Y" axis	
Model J-2.....	20"
Model J-3.....	20"
Rapid traverse rate.....	180 ipm
Milling feed rate.....	1-30 ipm
Positioning accuracy.....	± 0.001" in 24"
Repeatability.....	± 0.0005"
Tape input: 8 track perforated tape per EIA standard where possible.	
Smallest increment of positioning information..	0.0001"
Shipping weight, machine and control, approx:	
Model J-2.....	12,000 lbs.
Model J-3.....	13,700 lbs.

THE PRODUCT

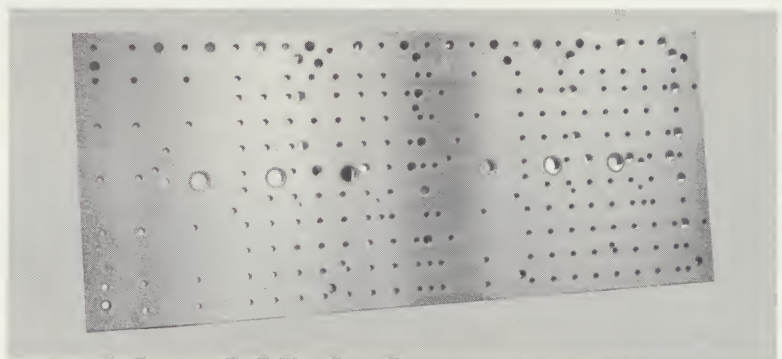
The transmission casting (center) is drilled, bored, reamed, tapped complete in two setups in a machine cycle of 38 minutes. This cast iron part is approximately 10" x 10" x 22" in size. The hole on top is not done in this operation.

The plate on the right, which is 3/4" CRS, is machined on the Drillmaster in 20 minutes. It comes to the machine rectangular in shape, 11" x 19". The radius in the notched out corner is put in with a 2 3/4" spade drill, the large hole (5 1/8" dia.) is trepanned. The smaller hole in the upper right hand corner is 1-11 1/2 N.P.T. The large C'Bore is not done in this operation for lack of tooling.

On the left side, the smaller plate, 1"—1018 HRS is drilled, bored, reamed, C'Bored complete in 21 minutes. A 2 1/4" end mill is used to make the flat bottom C'Bore.



This is the Universal Fixture Plate for the J-3 Drillmaster, 1" x 23" x 54"—1018 HRS. There are 202 drilled & tapped 1/2-13 holes, and 55 others ranging in size from 1/2" to 1 3/4". These are drilled only, and bored to size on a jig borer to ±.0005 in location. The 257 holes are finished in a machine cycle of 2 hrs. 49 min.



For more information on the Cleereman Drillmaster write to Cleereman Machine Tool Corp., Green Bay, Wisconsin

CLEEREMAN
MACHINE TOOL CORPORATION
Green Bay, Wisconsin

**Mark
Century**

For descriptive information on General Electric numerical control systems, write for bulletin GEA-7590, Distribution Services, General Electric Company, Schenectady, N. Y.

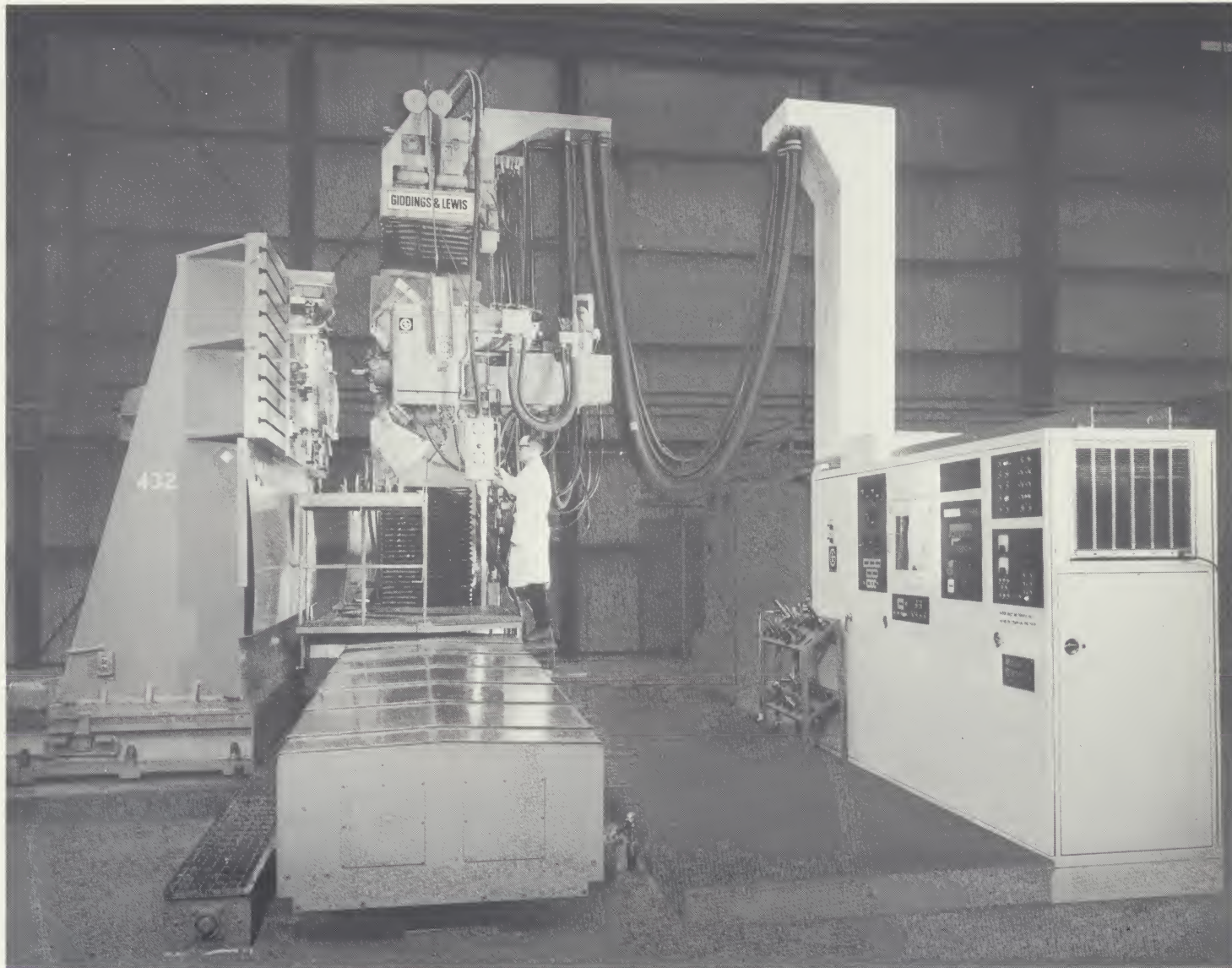
GENERAL ELECTRIC



Another example of modernized machining

Giddings & Lewis Variax Contour Milling Machine with General Electric Mark Century* Numerical Control

* Trade-mark of General Electric Co.



... provides 5 axes of simultaneous motion

FEATURES

- Full 5 axes of simultaneous contouring with linear interpolation
- 9.9999" and 99.999" block length
- High velocity loop-gain hydraulic servos permit contouring speed step-up to 180 ipm without programmed slow-down or loss of synchronism
- Individual manual-data-input thumb-wheel switches for all tape data
- Sequence number readout
- Photoelectric tape reader (500 cps)
- JOG/RUN/TRVERSE manual modes over complete speed range of machine
- System resolution 0.0001" and 0.001"
- Manual feedrate override, 0-120% in 10% steps
- Air conditioned
- Full-range zero-offset differential resolvers
- Sign reversing switches for each axis providing symmetrical cutting

OPTIONS

- Position readouts: cumulative command
- Automatic tape search by sequence number thumbwheel switch
- Part number readout
- GECENT postprocessor (APT)

DESCRIPTION

The Giddings & Lewis Variax Contour Milling Machine, with General Electric Mark Century numerical control, is a horizontal spindle, floor-type machine with five axes of simultaneous motion.

This floor-type design offers unlimited capacity for workpiece height. The angle plate is power-adjusted within a 34-inch range (increased ranges are available). Movements of the a-axis and b-axis cause the tool to pivot at the intersection of its

centerline and the tip of the tool, which results in greatly simplified programming.

Anti-friction ways for all controlled motions—combined with ball-nut or dual-pinion anti-backlash drives—provide this newly designed contour mill with advanced servo-drives fully equal in performance to the new control systems now available.

In addition, a new wide speed-range head features a cartridge-type spindle

which is quickly and easily replaced. The new head design also incorporates automatic variable preloading of bearings when spindle speeds are changed.

The basic travelling-column design of the machine permits two separate workholding areas for simultaneous machining and setup operations. It also permits machining long workpieces in a minimum of floor space.

NUMERICAL CONTROL FEATURES

- **A high-gain velocity loop servo** lowers machine maintenance costs, permits lower machine accelerations and decelerations, increases productivity, saves programming time, and shortens tape length.
- **Individual manual-data-input**

thumbwheel switches for each letter address code facilitates a convenient memory for inserting data into the system . . . lowering maintenance costs.

- **Numerical control service** is provided through a system of over 100 General Electric Mark Century Serv-

ice Engineers located in 48 cities, including all major machine-tool manufacturer locations.

- **GECENT 5-axis postprocessor** is available for APT users.

SPECIFICATIONS

Wide speed-range head 30 hp, 32 spindle speeds, 17 to 3600 rpm

Working length, X axis 168"

Working length, Y axis 48"

Depth adjustment of spindle, Z axis 18"

Transverse tilt, A axis $\pm 22\frac{1}{2}^\circ$

Longitudinal swivel, B axis $\pm 60^\circ$, -20°

Feed rates

X and Y axes 0 to 150"/min.

Z axis 0 to 60"/min.

Tilt (A) and swivel (B) 0 to 180°/min.

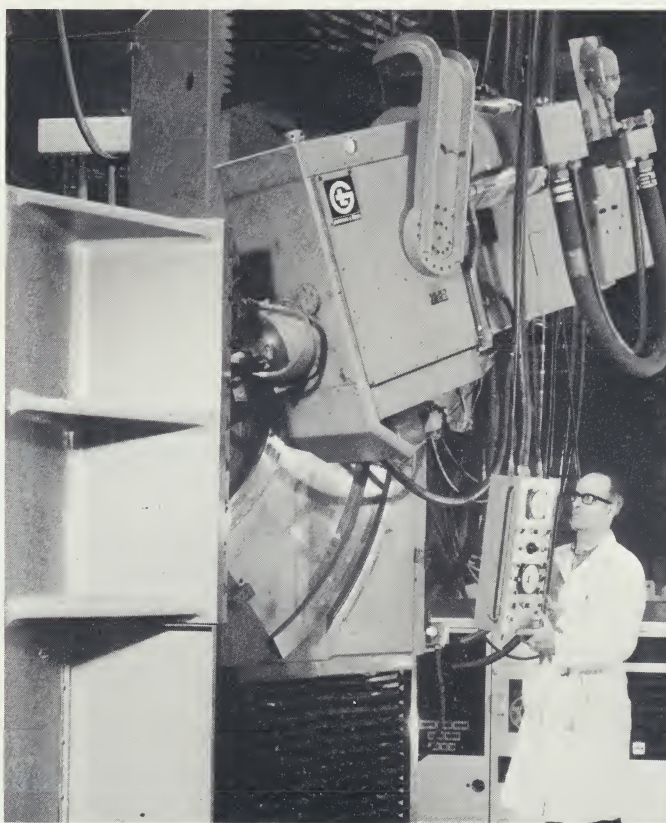
Anti-friction, anti-backlash construction throughout

Welded steel column

Lubri-Cool system for head to maintain controlled temperature of lubricating oil in head-stock

Pendant control of spindle functions

Remote power clamping for all tape-controlled motions



For more information on the Giddings & Lewis Variax Contour Milling Machine, write to Giddings & Lewis Machine Tool Company, Fond du Lac, Wisconsin 54936.

GIDDINGS & LEWIS

Machine Tool Company
Fond du Lac, Wisconsin 54936

Mark Century

For descriptive information on General Electric numerical control systems, write for bulletin GEA-7590, Distribution Services, General Electric Co., Schenectady, N. Y.

GENERAL  ELECTRIC

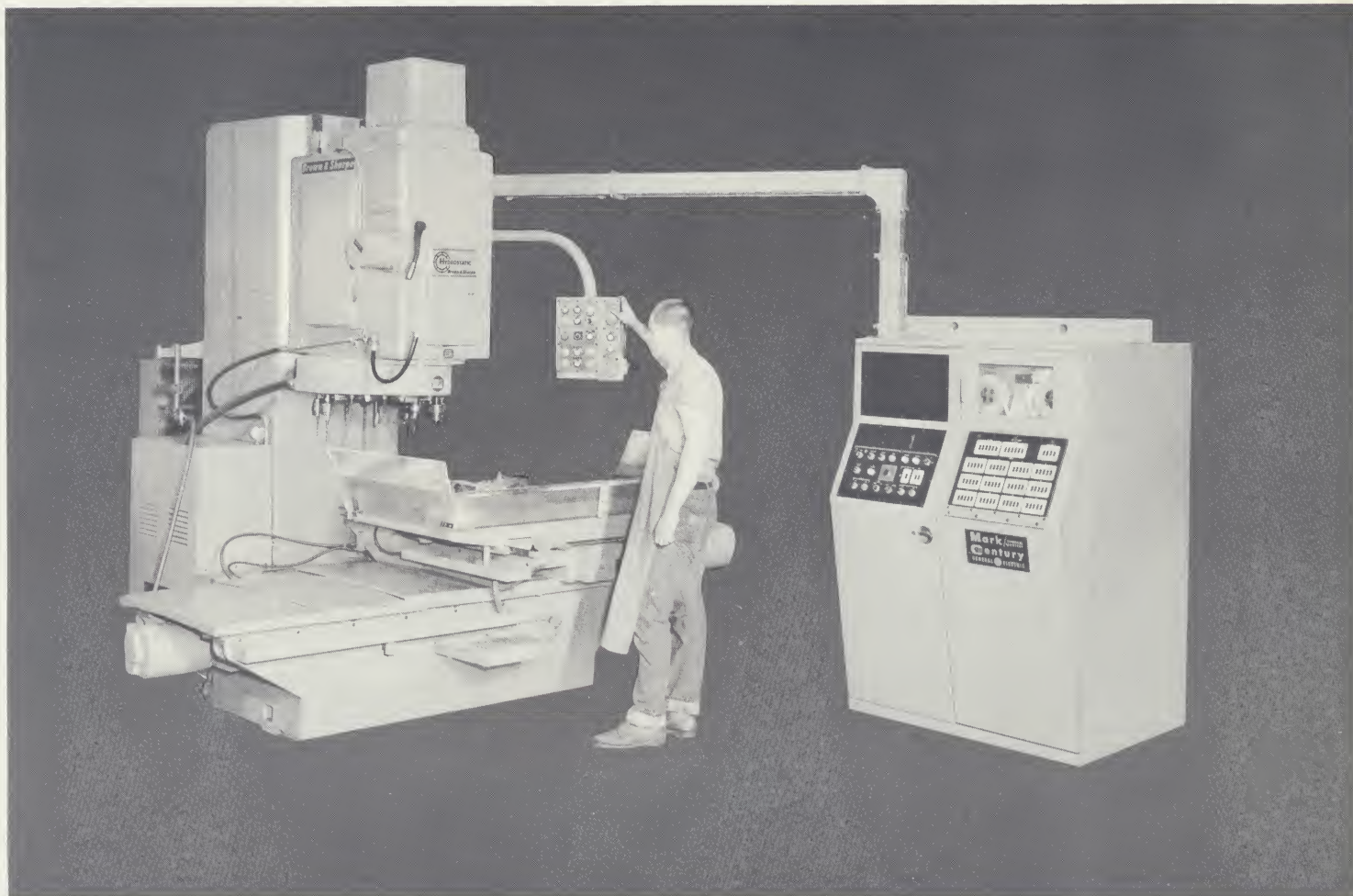
Another example of modernized machining . . .

Brown & Sharpe 3-axis HYDROTAPE

with

General Electric Mark Century* Numerical Control

*Trademark of General Electric Co.



drills, bores, taps, and mills in one simple set-up

FEATURES

- Tools automatically inserted in hydro-mechanically driven spindle.
- Up to 12 tools, stored in automatic tool positioner, are brought to spindle automatically in proper sequence.
- Mode (drill, drill and dwell, tap, bore, or mill) for each tool.
- Speed rates for each of 12 tools controlled by tape — automatically engaged and disengaged.
- 79 feed rates (0.5 to 39.5 ipm) for each of 12 tools.
- Depth of spindle feed and fast approach for each tool. No limit to number of depths that can be programmed for each tool.

- Positioning table movements, longitudinal and transverse.

DESCRIPTION

Brown and Sharpe HYDROTAPE automatic tool positioning machine with General Electric Mark Century 103P numerical positioning control drills, bores, taps, and mills in one simplified set-up.

During operation, each spindle has a variable speed range of 65 to 3000 rpm and can tap directly without added tapping heads. Time consuming drill changes are not required, thus speeding production.

Tape control automatically guides work-table positioning and spindle feed

simultaneously. All references are made to a fixed zero point to assure accuracy with any hole pattern. A simple work-holding device is the only tooling necessary—even for large pieces. This eliminates expensive jigs and fixtures.

NUMERICAL CONTROL FUNCTIONS

- Simultaneous longitudinal and transverse travel of table throughout any sequence — to any point.
- 12 tool offsets: each tool may be adjusted to the desired length. Range of adjustment is 9.9999".
- Table always approaches next position in same direction to eliminate backlash or wind-up errors.

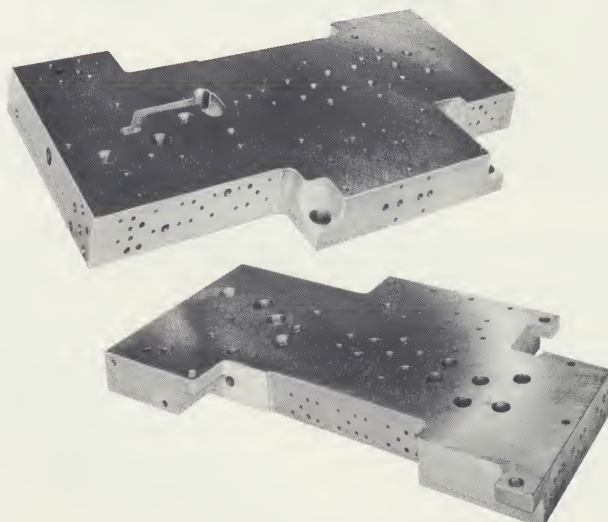
SPECIFICATIONS

Tape control model no.	232	233	234
Capacity (in free machining steel)			
Drill (diameters to — in.)	1 7/8	1 7/8	1 7/8
Tap (diameters to — in.)	1 1/2	1 1/2	1 1/2
Main Drive			
208-220/440V, 60 cycle, 1745RPM (HP)	15	15	15
Spindle			
Speeds	24	24	24
Speed range (RPM)	65-3000	65-3000	65-3000
Maximum tapping speed (RPM)	1000	1000	1000
Number of feeds	79	79	79
Feed rates (ipm)	.5-39.5	.5-39.5	.5-39.5
Rapid traverse rate (ipm)	200	200	200
Vertical travel (in.)	12 1/2	12 1/2	12 1/2
Head travel (in.)	13	13	13
Maximum Vertical Distance (in.) from end of tool holder to table top with tool holder for:			
#4 Morse taper	27 1/2	27 1/2	27 1/2
#3 Morse taper	28 1/2	28 1/2	28 1/2
1 3/8" straight shank	28	28	28
Throat distance (in.) C/L of spindle to face column	30	30	30
Spindle Head Power Positioning (ipm)	15	15	15
Maximum Number of Tools (in automatic positioner)	12	12	12
Hole in Tool Holders*	1 3/8" dia. straight hole (No. 4 Morse Taper when machine equipped with Tool Offset)		
Standard			
Special	Holders with #3 Morse Tapers and boring tool holders (ori- ented manually) with #4 Morse Taper or 1 3/8" straight holes.		
Positioning Table			
Table travel (in.)	15 x 20	25 x 30	25 x 48
Positioning speed (ipm)	200	150	150
Milling feed rate (ipm)	4 - 30	3 - 30	3 - 30
Positioning motors (2) Thymotrol DC	1/3	1/2	1/2
Work Surface (in.)	†20 x 30	26 x 58	26 x 58
Maximum work capacity (lbs.)	500	4000	4000
T-slots (number)	2	3	3
T-slots (width in.)	9/16	9/16	9/16
Height from floor (in.)	32	32	32
Hydraulic System Capacity (gals)	40	40	40
	(Oil cooled by heat exchanger)		
Lubricating System	Automatic — uses oil from hydraulic system		
Coolant System			
Capacity (gals)	10	10	10
Pump motor (hp)	1/3	1/3	1/3
	Coolant "On-Off" tape controlled		
Net weight (lbs)	12,400	13,000	13,300

*12 tool holders are furnished with 1 3/8" dia. straight holes. Exception: machines ordered equipped with tool offsets, when holders with No. 4 Morse Tapers are furnished.

†Includes coolant trough.

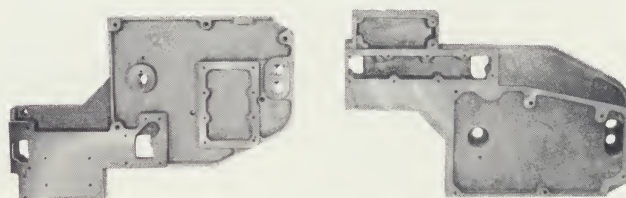
THE PRODUCTS . . .



Brown & Sharpe HYDROTAPE with G-E Mark Century numerical control set up and machined both sides of this part for a 49% time savings over the previous method. Set-up time was cut from 5 to 4 hours, and machining time from 5.8 to 1.5 hours.



With G-E Mark Century numerical control directing a Brown & Sharpe HYDROTAPE, set-up time on this part was cut 39% and machining time 46%. In addition, tooling costs were eliminated to save another \$3500.



To machine both sides of this part, conventional methods require three machines, 6 hours set-up time, .97 hour machining time, and \$3500 tooling costs. With Brown & Sharpe HYDROTAPE and G-E Mark Century numerical control, set-up takes 4 hours, machining .56 hours, tooling costs are eliminated, and all work is performed on one machine.



For more information on B&S HYDROTAPE and other machine tools, write to Brown & Sharpe Mfg. Co., Precision Park, North Kingstown, R. I. 02852.

B.S. Brown & Sharpe

**Mark
Century**
NUMERICAL CONTROL

For descriptive information on G-E numerical control systems, write for N/C DATA FILE GEZ-3774, Distribution Services, General Electric Co., Schenectady, N. Y.

GENERAL ELECTRIC

Another example of modernized machining

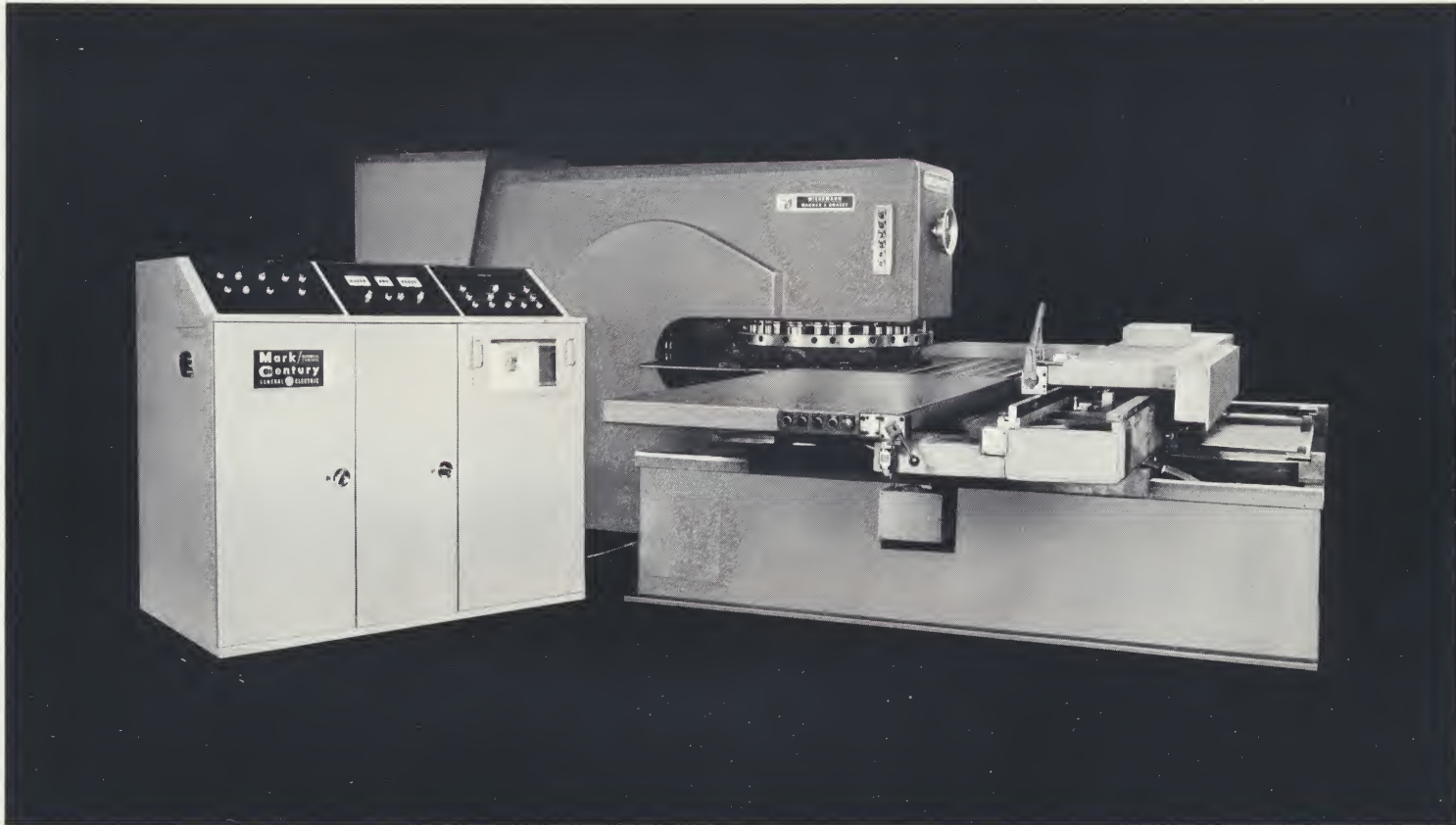
Wiedematic[†] A-30

with

General Electric Mark Century^{*} Numerical Control

[†] Trade-mark of Wiedemann Div., The Warner & Swasey Co.

^{*} Trade-mark of General Electric Co.



. . . provides flexible, rapid punching of sheet metal in a single handling

FEATURES

- 30-ton capacity
- $\pm 0.006''$ accuracy
- All tools turret mounted
- Fast punch and die installation
- Low tooling costs
- 55 holes per minute

DESCRIPTION

The Wiedematic A-30 turret punch press can produce openings of a wide variety of sizes and shapes in large and small parts. It does it all in a single handling and it's tape controlled by G.E.'s Mark Century numerical control.

Material is loaded . . . and a completed

part removed! Parts are stacked while the Wiedematic punches the next piece. The Wiedematic A-30 obsoletes multiple handling of lots and individual parts.

Further savings are realized with the A-30 as it requires no set-up, no layout, and no templates. All tools are in the turret, ready for immediate use.

The Wiedematic A-30's deep 50" throat (available also with 40" throat depth) handles nominal sheet material 48" x 96" —or 48" x 120" double handling—with material capacity of $\frac{1}{4}''$ thickness. Round and shaped holes up to $4\frac{3}{4}''$ diameter in $\frac{1}{8}''$ material as well as notches and cut-outs of practically unlimited variety are

all punched automatically by one machine with just one operator.

Another example of the versatility of the A-30 is its three-way positioning and punching control: it can function automatically, semi-automatically, or manually.

Power is provided by rotary hydraulic motors which position the table for each motion at 1,000" per minute and rapidly rotate the turret to the required station. The numerical positioning control operates the table, turret and press tripping to produce 55 hits per minute, maintaining $\pm 0.006''$ accuracy.

NUMERICAL CONTROL FUNCTIONS

- **Resolution** of 0.001" allows you to program 4-digit decimal equivalents of common fractions.
- **Absolute** dimensioning system rules out cumulative error.
- **Variable-block** word address format reduces programming time and length of input tapes.
- **Photoelectric** tape reader handles 100 characters per second.
- **Transistorized**, solid-state logic circuitry used throughout.
- **Full proportional** Hydraulic Motor servo system accurately positions at maximum punching rate.

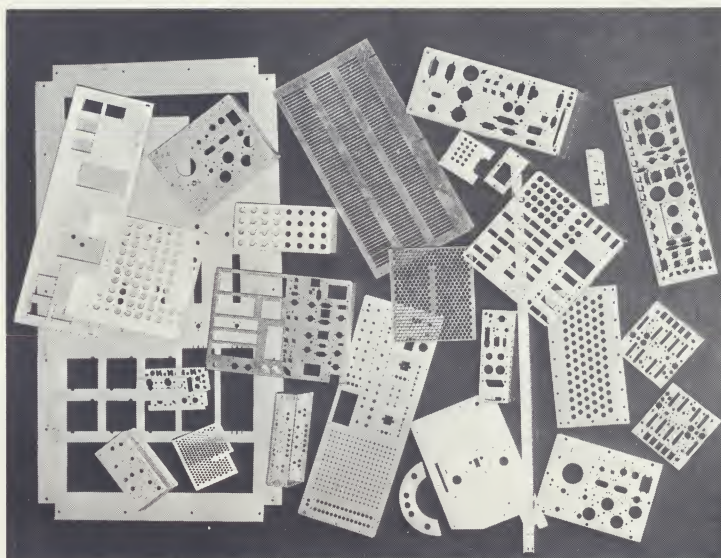
SPECIFICATIONS

Maximum Material Capacity.....	1/4"	Carriage Travel.....	1000 ipm
Press Capacity.....	30 tons	Stripper to Die Clearance.....	7/8" mounted in holders
Holes Per Minute.....	55 on 3" centers	Shipping Weight.....	approximately 35,000 lbs
Workpiece Size.....	48" x 96" nominal (48" x longer lengths with progressive movements)	Width.....	200"
Press Motor.....	5 hp, 1200 rpm, 220 or 440 volts, 3 phase, 60 cycle (voltage, phase and cycle altered to customer's requirements)	Depth.....	214"
		Height.....	81"
		Table Height.....	37 1/4"

THE PRODUCT...

Typical of the products produced with the Wiedematic A-30 are these parts of steel, brass, copper and aluminum. No tool changes were necessary in producing these intricate pieces as all tools are carried in the rotatable turrets. This is one of the basic features of all Wiedemann turret punch presses.

Punching these parts with the Mark Century numerically controlled A-30 is many times faster than by manual operation. More important, the elimination of errors associated with less reliable manual operation amounts to substantial savings of time and materials.



WIEDEMANN DIVISION

For more information on the Wiedematic A-30, write to Wiedemann Division, The Warner & Swasey Co., King of Prussia, Pa. 19406

WIEDEMANN DIVISION



THE WARNER & SWASEY CO.

Mark Century

For descriptive information of General Electric numerical control systems, write for N/C Data File, GEZ-3774A, Distribution Services, General Electric Company, Schenectady, N. Y.

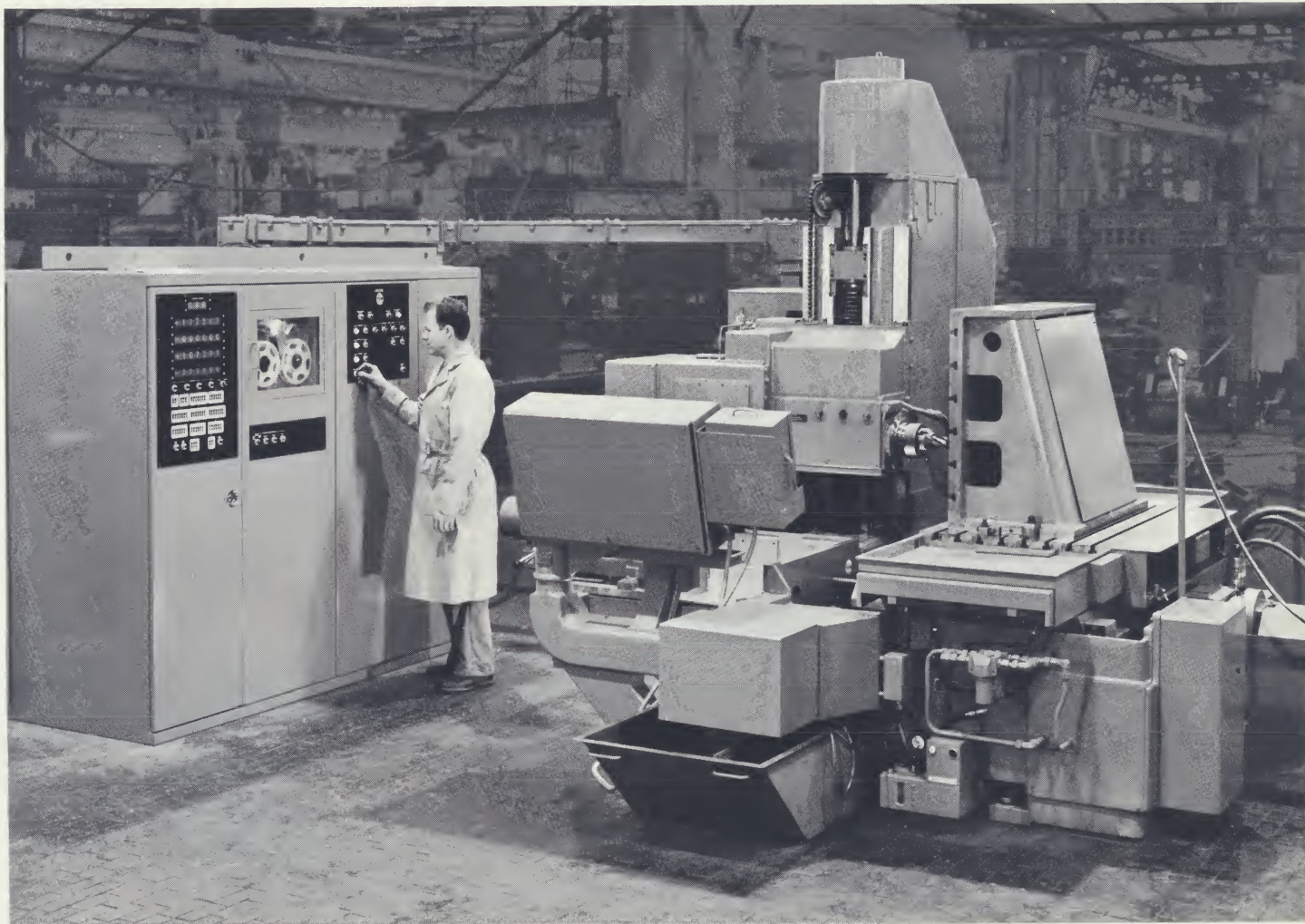
GENERAL  ELECTRIC

Another example of modernized machining

Pratt & Whitney NUMERIC-KELLER[®]

with

General Electric Mark Century* Numerical Control



... provides automatic, contour milling of two- or three-dimensional shapes

The new P&W Numeric-Keller machine with the G-E Mark Century numerical control system provides automatic, continuous-path, contour milling of two- or three-dimensional shapes. All machining operations—except set-up and tool changes—are directed by punched, coded tape, providing rapid and accurate milling of any job to exacting tolerances.

To set up a job, you simply position the workpiece, install the cutting tool and put the tape in the tape reader. The control system does the rest—resulting in a production and/or lead-time savings of up to 75 percent. Tooling costs can be reduced as much as 80 percent.

Both "continuous-position readout" and "jogging" controls are provided to

facilitate set-up and tool-changing. Digital readout indicators continuously monitor the exact position of the cutter, on all axes at every point in the program. "Jogging" controls permit the operator to stop the machine, withdraw the spindle, change the cutting tool, return the cutter to the machining position, and resume machining under tape control without losing synchronization.

Up to 96 auxiliary functions can be programmed in the tape, including tape-searching circuitry for automatic advancing and re-winding of the tape and turning the coolant on and off.

FEATURES

- Small lot, repeat production
- Repeatable accuracy to 0.001 inch
- Simplified tape preparation

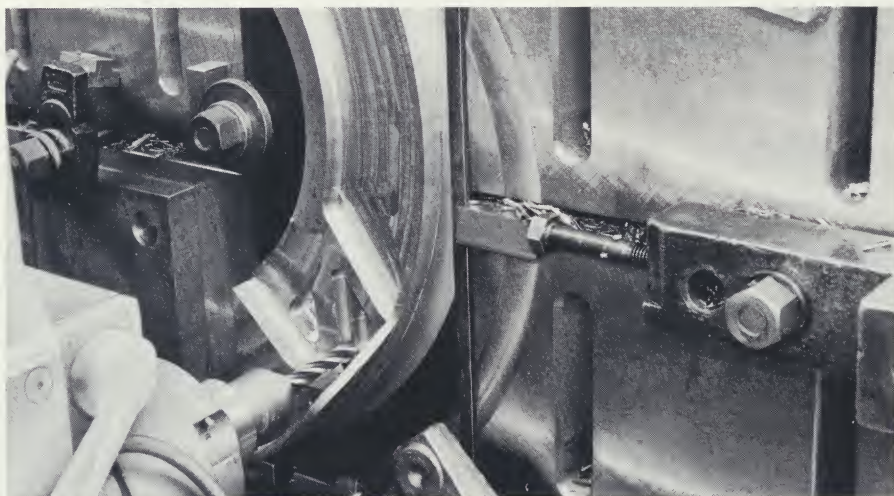
- Cutter position read-out
- Extremely rigid for high-torque milling
- Feed rate over-ride capability
- Three-point spindle support to eliminate deflection
- Feed range from 0 to 90 inches per minute; 0 to 180 inches per minute optional
- Manual Data Input capability

MACHINE/CONTROL FUNCTIONS

- Drilling, tapping, boring, threading
- Elliptical-path milling
- Two- or three-dimensional contour milling
- Radius-opening milling
- Pocket milling
- "Mirror image" machining

* Trade-mark of General Electric Co.

The product...



Machining capability

Here's an example of the work performed on the Numeric-Keller with the Mark Century numerical control system. Four roughing and finishing pocket cuts and three roughing and finishing contour cuts were milled on this missile component. Total machining time was 21.5 hours.

Reduced costs

Pratt & Whitney's Numeric-Keller contour millers—directed by General Electric's Mark Century numerical controls—reduce costs in practically all areas.

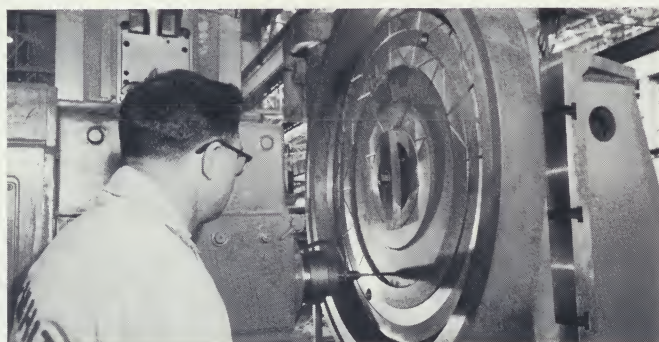
Punched tape replaces the template, cam, or model used on tracer-controlled machines, resulting in production and/or lead time savings of 75 percent. Set-

ting up jobs requires only positioning of the work piece, installation of the cutting tool, and putting the tape into the control unit. Tooling costs have been reduced up to 80 percent.

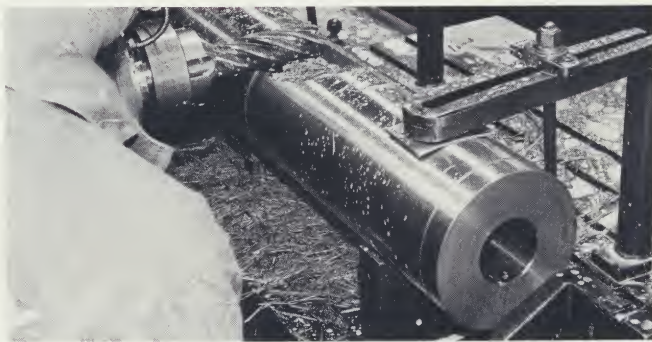
Tape-controlled operation means "predictable productivity," because production time can be exactly determined. Set-up, machining time, and costs can

be scheduled for maximum efficiency.

Typical of time reductions is the milling of a radius opening for a trunnion sleeve. Conventionally, 3.12 hours were needed; with the Numeric-Keller, only 1.02. For milling oil grooves, machining time was slashed from 5.43 to 1.13 hours.



Milling oil grooves



Milling a radius opening

Tape preparation

Application of latest computer techniques to machine tool tape preparation has drastically reduced the problem of converting engineering data into the tape for machine tool control.

The APT programming system, backed by the specially developed GECENT postprocessor, enables the process planner to use word descriptions when preparing information for

the computer. Areas of the finished part—and relationships of these areas to one another—are described in English language terms.

NUMERIC  **KELLER**®

For detailed information on Pratt & Whitney's NUMERIC-KELLER tape-controlled continuous-path millers, write for Bulletin A22, Pratt & Whitney Company, Charter Oak Blvd., West Hartford, Connecticut.



PRATT & WHITNEY
A MAJOR INDUSTRIAL COMPONENT OF
FAIRBANKS WHITNEY

**Mark
Century**

For descriptive information on G-E Mark Century numerical contouring or positioning control systems write for Bulletin GEA-7590, Distribution Services, General Electric Company, Schenectady, N. Y.

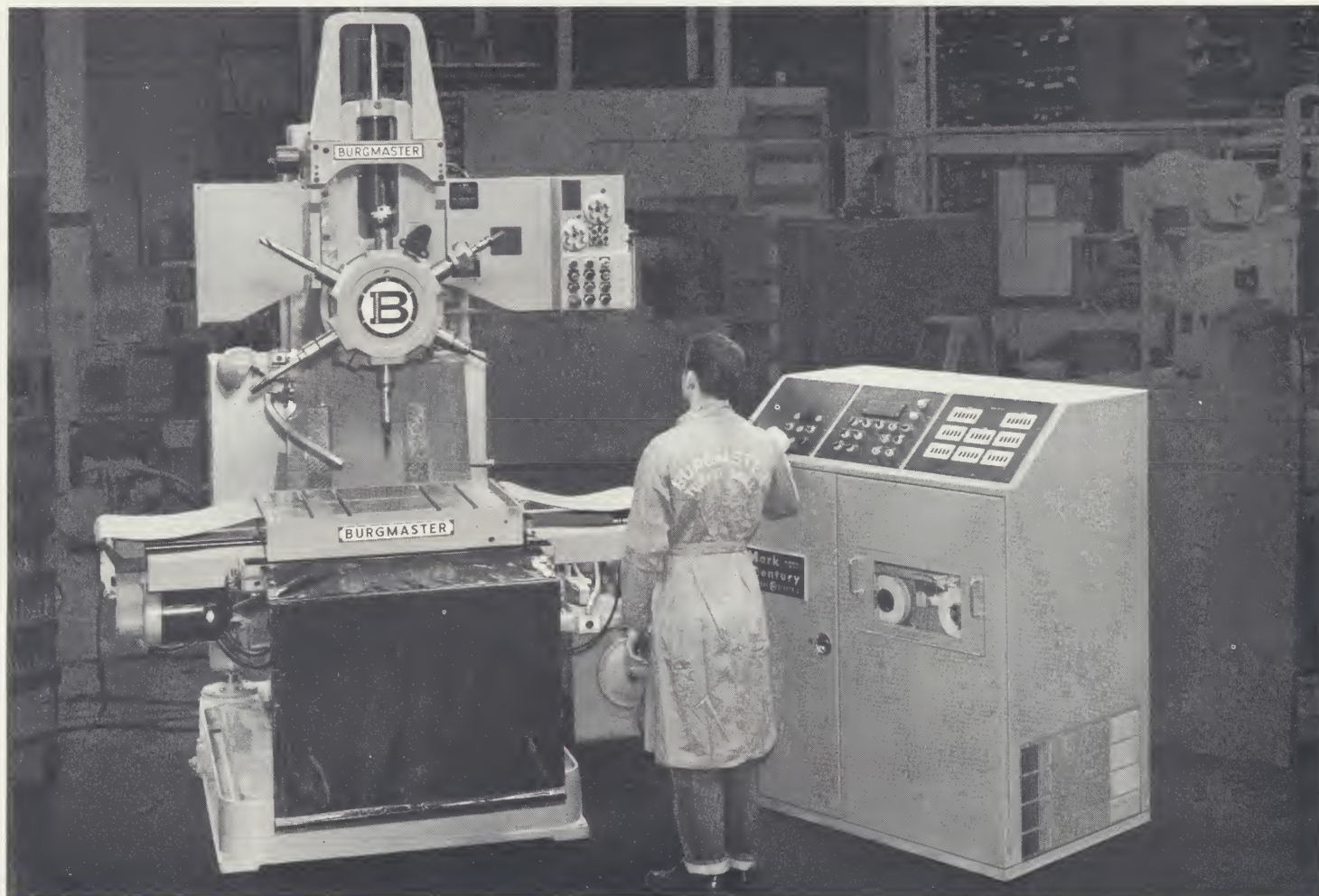
GENERAL  **ELECTRIC**

Another example of modernizing machining

BURGMASER 25AHT-L Automatic 6-spindle Turret Drilling Machine

with

General Electric Mark Century* Numerical Control



... provides increased profits for drilling, tapping, and boring small lots

FEATURES

- Greatly reduced lead time for production—ideal for small lots
- Simplified tooling eliminates expensive fixtures; drill bushings not required
- Punched tapes are quickly made or corrected
- Lower labor costs—only semi-skilled operator is needed
- Less spoilage—not affected by operator's skill
- Greater accuracy of hole location—table positions automatically
- Increased tool life—feeds and speeds are preselected for greater efficiency
- Reduced inspection—center dimensions automatically controlled

- Easy to operate—one operator can run two or more machines, inspect, deburr, etc.
- Replaces 6-spindle in-line drills, radial drills, jig borers (for many applications), multiple drill and tap heads, expensive fixtures, layout drills, etc.

SPECIFICATIONS —

Models 25AHT-L and 25AHT-XL

Horsepower — 5
Turret travel — 10 inches
Throat depth — 23 or 33 inches
X-Y table travel — 20 x 30 or 30 x 45 inches
Speed range — 30 to 2000 rpm
Spindle to table — 26 inches or more
Capacity — 1¼ inches in steel
Individual tool zeroing (Full range random tool length compensation)

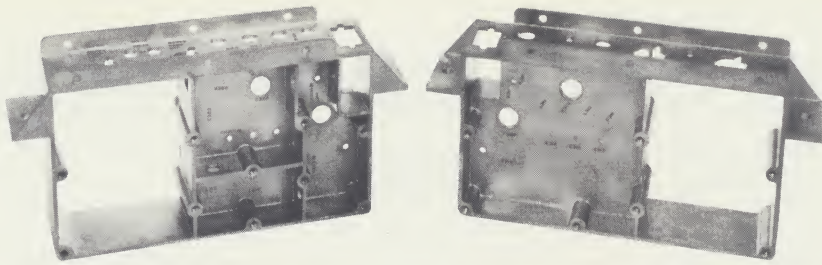
MACHINE CONTROL AUTOMATIC FUNCTIONS

- Positions table in two axes
- Selects spindles in any sequence
- Controls rapid traverse lengths of tools in Z axis
- Controls tool depth
- Selects spindle speeds
- Selects spindle feed rates
- Clamps both axes while operations are performed
- Controls table feed lengths for milling
- Actuates selective dwell

Optional Tape-controlled Functions

- Coolant on-off
- Chip blowing
- Index fixture
- Reciprocating feed

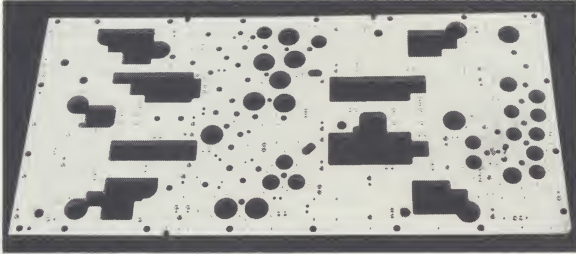
*Trade-mark of General Electric Co.



THE PRODUCTS . . .

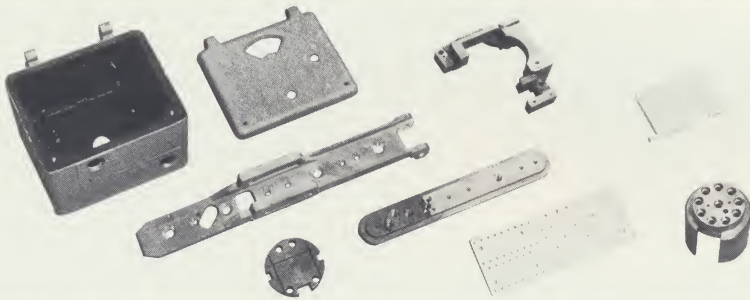
Oscillator Chassis

This oscillator chassis, machined by a Burgmaster with G-E Mark Century numerical control, required 27 different drilling operations. Twenty-two minutes per part were saved over former conventional methods in lot sizes of 40 units; \$224 in tooling costs were saved with Burgmaster.



Digital Computer Base

Over 1000 center drilling, tapping, and reaming operations were performed on this computer base plate by the Burgmaster Tape-controlled Turret Drilling Machine. In lot sizes of 10, 5.1 hours per part, 90 percent of labor costs and \$1850 fixture costs were saved over previous methods.



Miscellaneous Parts — Lot sizes of 15 to 20

In one installation, 310 jigs were eliminated in the first 120 days. Now, more than 2000 parts are programmed on tape with savings up to 400 percent. These typical small-lot parts were machined from aluminum, brass, steel, and fiberglass on a Burgmaster which runs 16 hours per day, five days a week.



Small-lot Parts

Over 96 parts are programmed on tape. One—a gate limit valve cage of hard naval brass—has 56 different holes automatically center-drilled, bored, and reamed in just 23 minutes. Production on this operation alone has been increased three to four times over the formerly used box jig method. The savings are 45 minutes per part.



Die Cast, Steel, and Aluminum Camera Parts

Burgmaster saves 30 percent of set-up time, 53 percent of machining time, and 51 percent of tooling costs by combining milling operations with drilling, tapping, boring, counter-sinking, and counterboring on job lots of less than fifty units.

For detailed information on Burgmaster 6- and 8-spindle automatic turret drilling machines, write to Burgmaster Corporation, P. O. Box 311, 15001 South Figueroa Street, Gardena, California.



BURGMAS-TER CORPORATION

Mark Century

For descriptive information on G-E Mark Century numerical contouring and positioning control systems, write for Bulletin GEA-7590, Distribution Services, General Electric Company, Schenectady, N. Y.

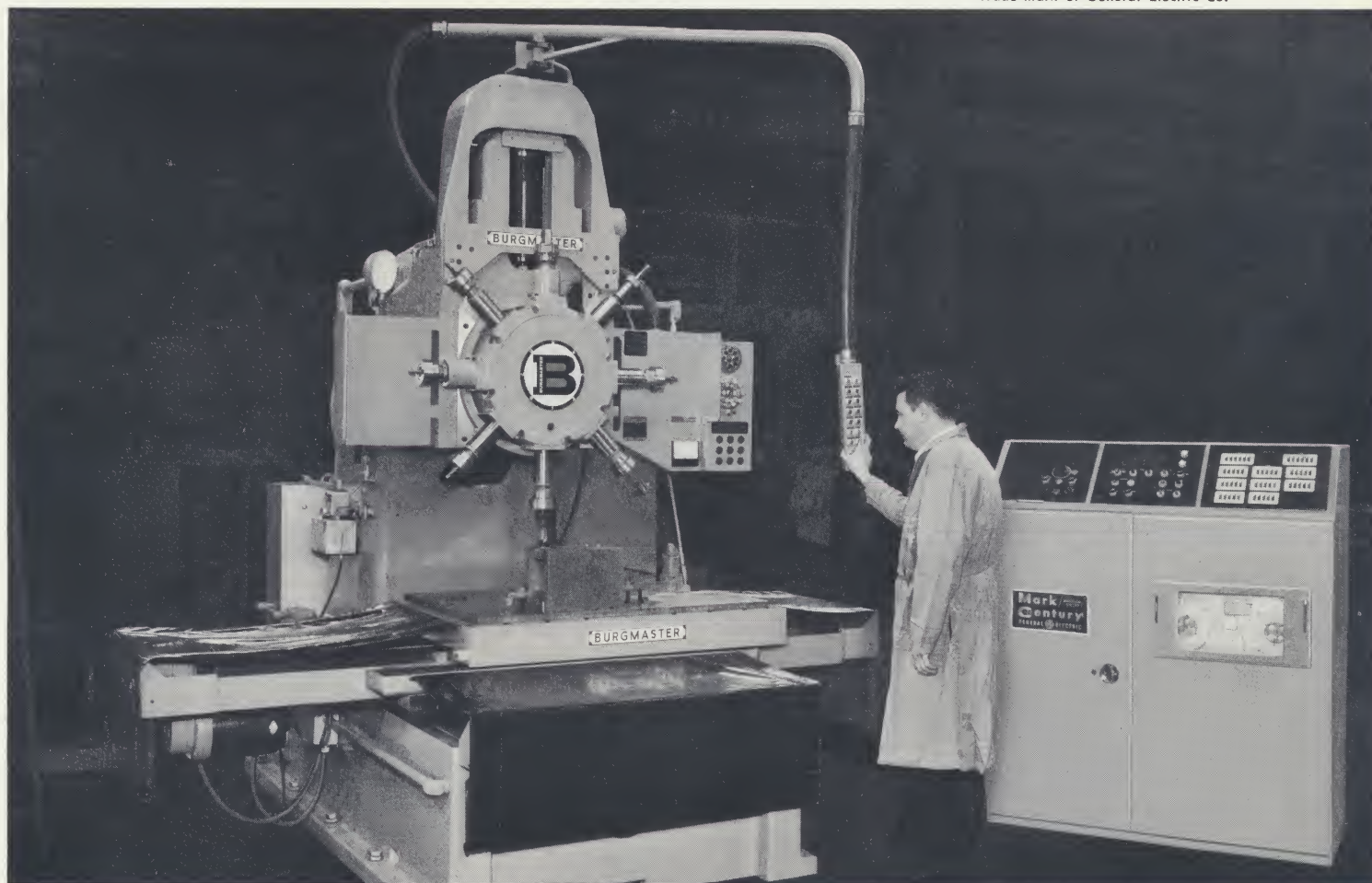
GENERAL ELECTRIC

Another example of modernized machining

Burgmaster 3BHT-L Automatic 8-spindle Turret Drilling Machine

with
General Electric Mark Century* Numerical Control

*Trade-mark of General Electric Co.



... provides more, high quality drilling, tapping, milling, and boring at low cost

FEATURES

- Greatly reduced lead time to get into production—ideal for small lots
- Simplified tooling eliminates expensive fixtures; drill bushings not required
- Punched tapes are quickly made or corrected
- Lower labor costs—only semi-skilled operator is needed
- Less spoilage—not affected by operator's skill
- Greater accuracy of hole location—table positions automatically to ± 0.001 inch, repeatable to ± 0.0005 inch
- Increased tool life—feeds and speeds are preselected for greater efficiency
- Reduced inspection—center dimensions automatically controlled

- Easy to operate—one operator can run two or more machines, inspect, deburr, etc.
- Replaces 8-spindle, in-line drills, radial drills, jig borers (for many applications), multiple drill and tap heads, expensive fixtures, layout drills, etc.

SPECIFICATIONS—Models 3BHT and 3BHT-L

Horsepower — 7.5
Turret travel — 12 inches
Throat depth — 23 or 33 inches
X-Y table travel — 20 x 30 inches, 30 x 45 inches
Speed range — 30 to 2000 rpm
Spindle to table — 35 inches (table-type), 24 inches (bed-type)
Individual tool zeroing (random tool length compensation for each spindle)

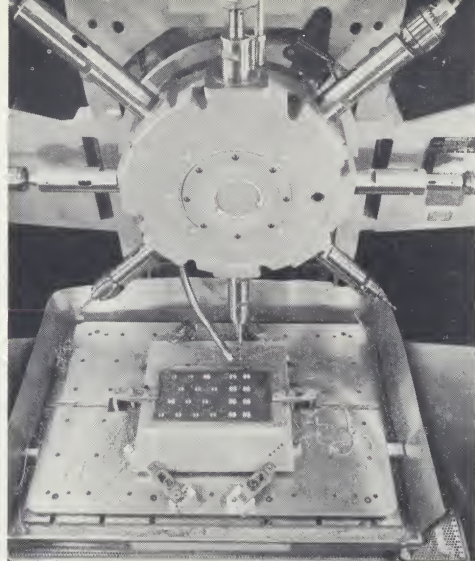
MACHINE CONTROL AUTOMATIC FUNCTIONS

- Positions table in two axes
- Selects spindles in any sequence
- Controls length of rapid approach to work piece
- Selects spindle speeds
- Controls tool depth
- Selects spindle feed rates
- Clamps both axes while operations are being performed
- Selects dwell cycle
- Controls length of milling cuts in X and Y axes

Optional Tape-controlled Automatic Features

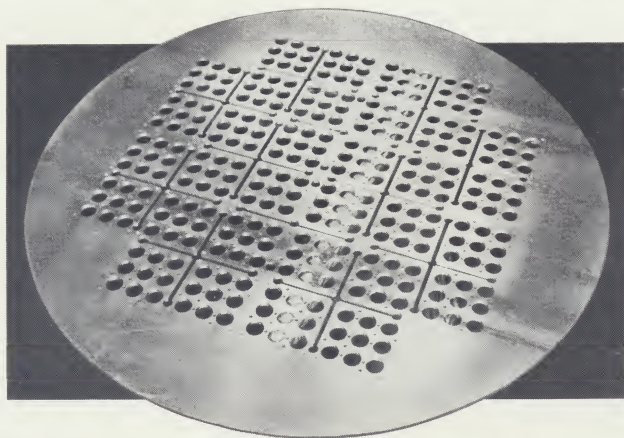
- Coolant on-off
- Chip blowing
- Index fixture
- Reciprocating feed

THE PRODUCTS...



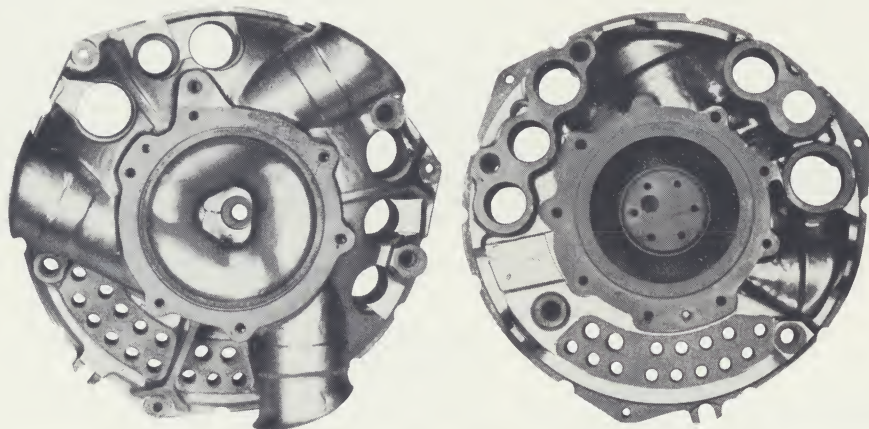
Instrumentation Panel

The Burgmaster 8-spindle machine with G-E Mark Century numerical control performs 268 operations on 100 holes eight times faster than previous methods. During machining, one tool change is made on two spindles. Note the simple holding clamps. Over-all savings during the first year of operation paid for the machine.



Nuclear Reactor Grid Plate

A total of 2,098 machining operations—all within 0.004 inch tolerance—are performed on this nuclear reactor grid plate, reducing production time from eight weeks to nine days. Also, the Burgmaster saved 60 hours of lead time and eliminated an \$800 fixture. All drilling, tapping, boring, and milling operations are performed in one set-up.



Magnesium Manifold Housing

For this manifold housing, 32 different tools and 172 operations are required, including center drilling, spotfacing, core drilling, boring, counter sinking, reaming, port cutting, tapping, and milling. Formerly, it took 28 hours per unit in lots of 10. Now, on the Burgmaster, the same parts are machined in 18 hours each—a production increase of 56 percent. Rejects have been eliminated . . . along with \$5000 worth of jigs and fixtures.

For detailed information on Burgmaster 8-spindle automatic turret drilling machines, write to Burgmaster Corporation, P.O. Box 311, 15001 South Figueroa Street, Gardena, California.



BURGMAS-TER CORPORATION

Mark Century

For descriptive information on G-E Mark Century numerical contouring and positioning control systems, write for Bulletin GEA-7590, Distribution Services, General Electric Company, Schenectady, N. Y.

GENERAL ELECTRIC

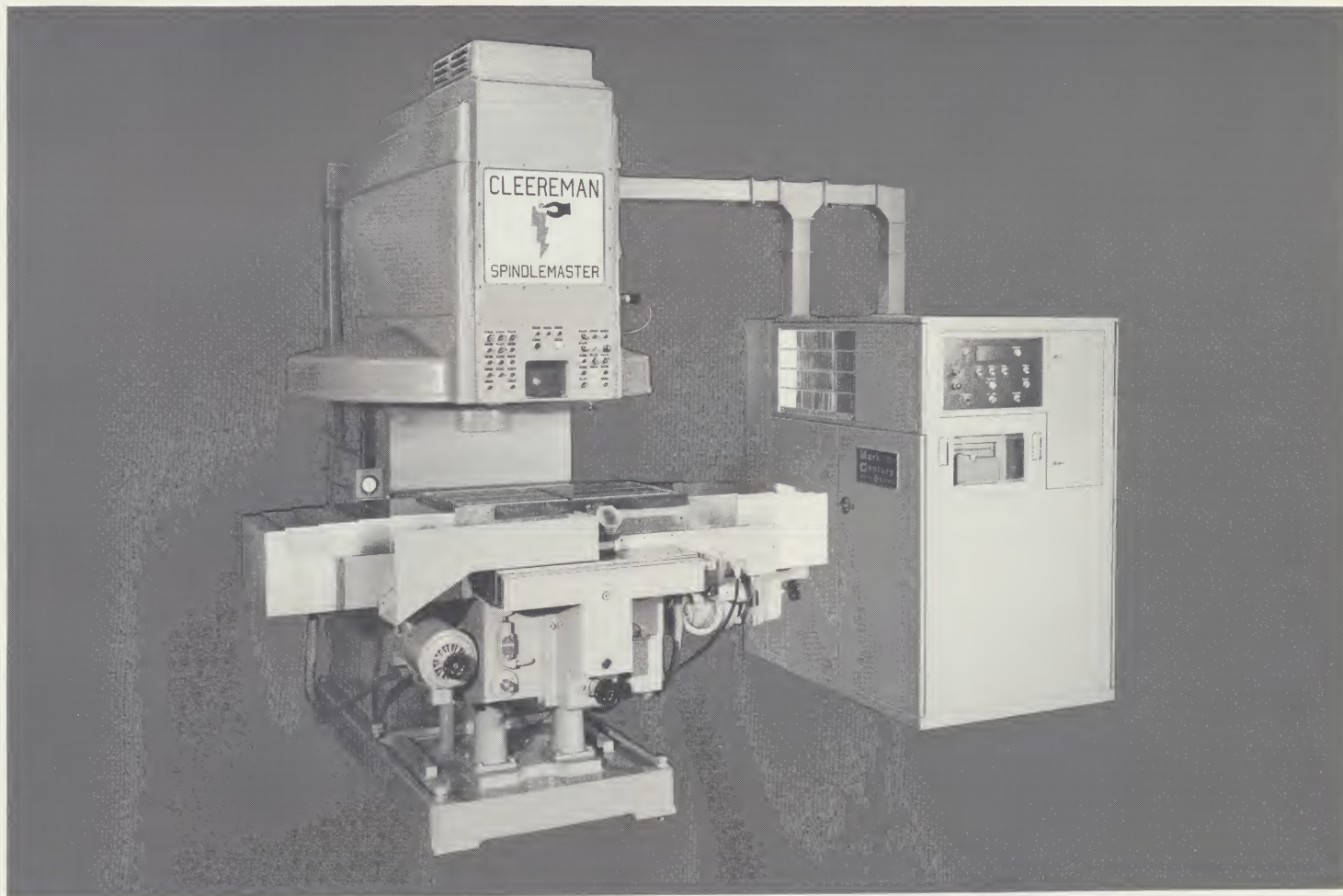
Another example of modernized machining

Cleereman SPINDLEMASTER

with

General Electric Mark Century* Numerical Control

*Trade-mark of General Electric Co.



... provides flexible automation for drilling, tapping, boring, reaming, milling

The Cleereman Spindlemaster is a vertical-spindle machine tool with automatic tool change and General Electric Mark Century numerical positioning control.

Spindlemaster can drill, tap, ream, mill, and bore to precision tolerances—changing tools as needed from a magazine that holds as many as 30 tools—without any break in the machining cycle.

It can pay for itself quickly because of savings in set-up time, operating time, and improved performance. Many operations are performed on one machine in a single cycle with simple preparation for production of repeat orders and easy design changes. The machine is designed for accuracy and precision within 0.001 inch. All machine functions are fully automated by punched-tape commands.

FEATURES

- 30-station automatic tool changer
- Quill-type precision boring spindle
- Adjustable table knee with twin screw jacks
- Severe-duty-cycle spindle drive
- Convenient operator's controls
- Head oil temperature thermostatically controlled to prevent thermal drift
- Workpiece indexer (optional)

MACHINE/CONTROL FUNCTIONS

Tool selection—One of 30 different tools can be selected by tape command. As the spindle moves through the tool magazine, the tool is mechanically loaded or unloaded in the spindle collet.

Spindle control—One of 18 spindle speeds, arranged in geometric progression, is

selected by tape command. Also, start, stop, and direction of rotation are established by tape command.

Spindle positioning and feed—The spindle can be positioned at 150-inches-per-minute rapid traverse rate. For feeding in the cut, seventy-nine feed rates from 0.5 to 19.75 ipm are provided in 0.25 ipm steps.

Table and saddle positioning and feed—The table and saddle can be positioned at 200 ipm simultaneously or individually. For milling operations, 79 feed rates from 0.5 to 19.75 ipm are provided in 0.25 ipm steps.

Coolant control—Coolant is turned on and off by tape command.

Dwell time—To clean up a cut, a dwell time can be programmed to apply at the end of a cut, involving any axis.

Full-range zero offset for x and y axes—Zero can be set anywhere in range of x and y travel.

Manual data input—All command functions can be manually input on convenient thumbwheel switches for semi-automatic operation.

Manual jog/traverse controls—Tool magazine and all motions can be operated manually for set-up and maintenance.

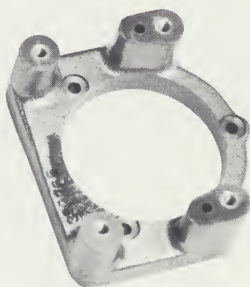
Power-operated knee—A motor drive is provided to adjust knee position.

Operational workpiece indexer—A tape-controlled workpiece indexer is available to permit machining different faces on a given piece.

SPECIFICATIONS

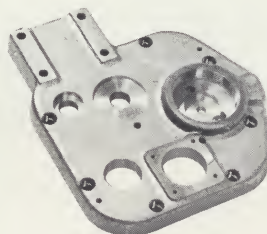
Table size.....	16 x 30 in.
Table travel.....	16 x 24 in.
Spindle travel.....	10 in.
Table knee vertical adjustment.....	9 in.
Spindle-to-table maximum distance.....	19 in.
Number of spindle speeds.....	18
Spindle speed range.....	150 to 3125 rpm
Spindle drive motor, 2-speed, rapid reversing.....	5/2 1/2 hp
Spindle feed range.....	0.5 to 19.75 ipm (79 steps)
Spindle rapid traverse rate.....	150 ipm
Table milling feed range.....	0.5 to 19.75 ipm (79 steps)
Table rapid traverse rate.....	200 ipm
Maximum tools carried in magazine.....	30
Maximum tool diameter for magazine clearance.....	4 in.
Hole-location positioning accuracy.....	± 0.001 in 12 in.
Repeatable positioning accuracy.....	± 0.0005 in.
Feed depth accuracy.....	± 0.001 in.

THE PRODUCT...



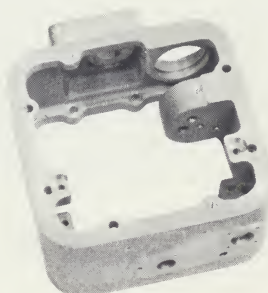
Differential Motor Bracket

The Spindlemaster—with General Electric Mark Century control — performed milling, drilling, reaming, boring, spotfacing, and tapping operations on this magnesium part in 13 minutes. By combining four set-ups into one, machining time was reduced 60 percent. Tooling costs were reduced \$300.



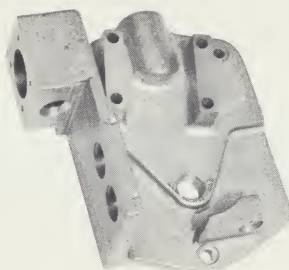
Cover

In 29 minutes, milling, drilling, spotfacing, boring, reaming, tapping, and counterboring were performed on this aluminum cover — reducing machining time 49 percent by combining seven set-ups into one. Tooling costs were reduced \$1000.



Cover

On this aluminum cover, machining time was cut 62 percent for the first set-up and 72 percent for the second set-up. Milling, drilling, boring, tapping, counterboring, spotfacing, and countersinking operations were performed. Twelve minutes were needed for the first set-up and 14 minutes for the second. For the first set-up, two previous set-ups were combined; for the second, three were combined.



Torque Control Body

An 82 percent saving in machining time resulted in milling, drilling, boring, tapping, and spotfacing this aluminum part. Eight set-ups were combined into three, reducing time cycle to 72 minutes. Tooling costs were cut \$625.



For detailed information on the Cleereman Spindlemaster machine tool, write for Catalog No. 363, Cleereman Machine Tool Corporation, Green Bay, Wisconsin.

**CLEEREMAN
MACHINE TOOL CORPORATION**

Mark Century

For descriptive information on G-E Mark Century numerical contouring and positioning control systems, write for Bulletin GEA-7590, Distribution Services, General Electric Company, Schenectady, N. Y.

GENERAL  ELECTRIC

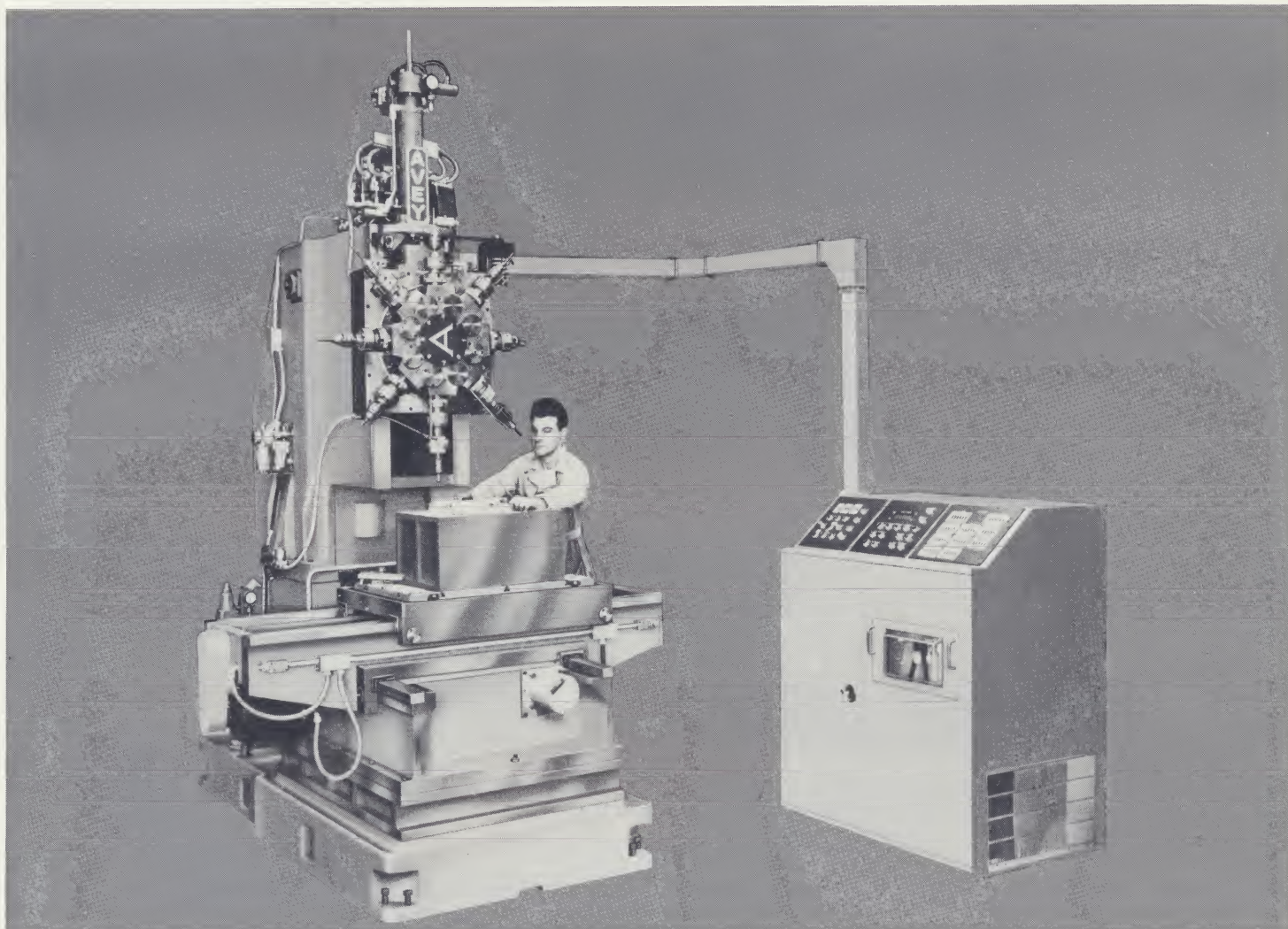
Another example of modernized machining

Avey TURRET-DEX Eight-spindle Automatic Drilling Machines

with

General Electric Mark Century* Numerical Control

*Trade-mark of General Electric Co.



. . . perform high quality drilling, tapping, and boring operations

The Avey Turret-Dex eight-spindle turret-type machine tool with General Electric Mark Century three-axis numerical control drills, taps, mills, deep-hole drills, spotfaces, and bores. It has a two-axis work positioning table with hardened and ground ways and recirculating roller bearings.

The machine features tape-selected speeds and feeds as well as drill, dwell, mill, bore and tapping cycle for any or all spindles. The eight-spindle turret-saddle slides on hardened and ground rectangular steel ways.

FEATURES

- Heavy-duty alloy steel spindles mounted in tapered roller bearings
- Tape selection of speeds and feeds
- Rigid turret support
- Automatic mist-type lubrication constantly lubricates all moving parts

MACHINE/CONTROL FUNCTIONS

- Turret indexing

- 2-axis table positioning
- Z-axis control
- Turret feed length, traverse, and retraction
- Adjustment of light-duty milling feeds on positioning table
- Spindle speed and penetrating rate
- Flood and spray coolant flow
- Machine dwell, bore, drill, and tap cycling

AVEY TURRET-DEX SPECIFICATIONS

	No. 200	No. 250	No. 300		No. 200	No. 250	No. 300
Drill Capacity, Mild Steel	1"	1¼"	1½"	Spindle Construction	Double row ball bearing	Tapered roller bearings	
Tap Capacity, Mild Steel	1"	1¼"	1½"	Turret Feed Cylinder	2½"	3¾"	3¾"
Turret Travel	8"	12"	12"	Tapping Cycle	Std. equipment—all spindles		
Number of Spindles	8	8	8	Dwell Accuracy	±0.001	±0.001	±0.001
		10 optional		Spindle Runout	0.0005"		
Spindle Horse Power	2	5	5-7½	Number of Spindle Speeds	4	12	12
Turret Feed Rates	15	15	15		8 optional	24 optional	24 optional
	99 optional	99 optional	99 optional			240 ipm	
Turret Feed	Hydraulic-pressure & temperature compensated			Rapid Traverse Rate	Hardened and ground ways		
Standard Spindle Bore	1"	1¾"	1⅞"	Turret Saddle Construction	Hydraulic with positive shotbolt locating		
Hydraulic Power Unit	5 hp variable volume			Index Mechanism			

AVEY POSITIONING TABLE SPECIFICATIONS

	SB*	SE*	L*	LL*		SB*	SE*	L*	LL*
Table Travel	20" x 30"	20" x 30"	25" x 35"	30" x 40"	Rapid Traverse Rate	150 to 200 ipm			
Work Surface	24" x 34"	24" x 34"	30" x 40"	30" x 40"	Positioning Accuracy	±0.001			
Way Construction	Hardened and ground rectangular ways with recirculating roller bearings				Ball Bearing Lead Screw	1½"-4	1½"-4	1¾"-4	1¾"-4
Clamping	Independent magnetic clamps each axis				Throat Required	24½"	24¼"	29½"	34½"
Drive Motors, Each Axis	½ hp	½ hp	¾ hp	¾ hp	Work Load Capacity	1500 lbs	1500 lbs	2500 lbs	5000 lbs
Tee Slots, X Axis	—	—	3-½ hp	3-½ hp	Table Type	Double screw			
Tee Slots, Y Axis	2-½"	2-½"	2-½"	2-½"	Bed	Elevating	Bed	Bed	Bed
					Way Covers	Mylar roll-up—std. equipment			

*KEY

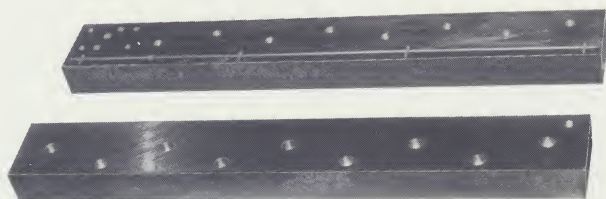
S —20" x 30" Table
L —25" x 35" Table
LL—30" x 40" Table
B —Rigid base table
E —Elevating table

MODEL
 No. 200-SE, SB
 No. 250-SE, SB
 No. 250-L
 No. 250-LL

APPROXIMATE SHIPPING WEIGHTS

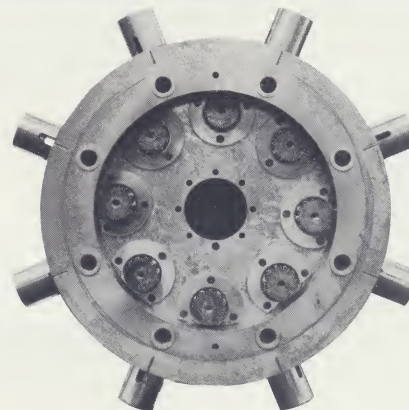
WEIGHTS	MODEL	WEIGHTS
10,000 lbs	No. 300-SE, SB	19,000 lbs
18,000 lbs	No. 300-L	25,000 lbs
23,000 lbs	No. 300-LL	26,000 lbs
24,000 lbs		

THE PRODUCT . . .



Slide Retainer

For this part, three set-ups were combined into one. Machining time was reduced 60 percent. Previously performed operations were jig boring, upright drilling, and vertical milling for the holes and the oil grooves.



Turret

Drilling, tapping, and rough boring were performed on this turret in the first set-up and jig boring was performed in the second set-up, with a reduction of 115 hours. Elimination of one set-up—plus the efficiency of Turret-Dex with Mark Century numerical control—made possible the 50 percent saving in machining time.



For detailed information on Avey Turret-Dex eight-spindle machine tools, write for Bulletin 263, The Avey Division of Motch & Merryweather Machinery Company, Cincinnati 1, Ohio.

THE AVEY DIVISION
 of the **MOTCH & MERRYWEATHER MACHINERY CO.**



For descriptive information on G-E Mark Century numerical contouring and positioning control system, write for Bulletin GEA-7590, Distribution Services, General Electric Company, Schenectady, N. Y.

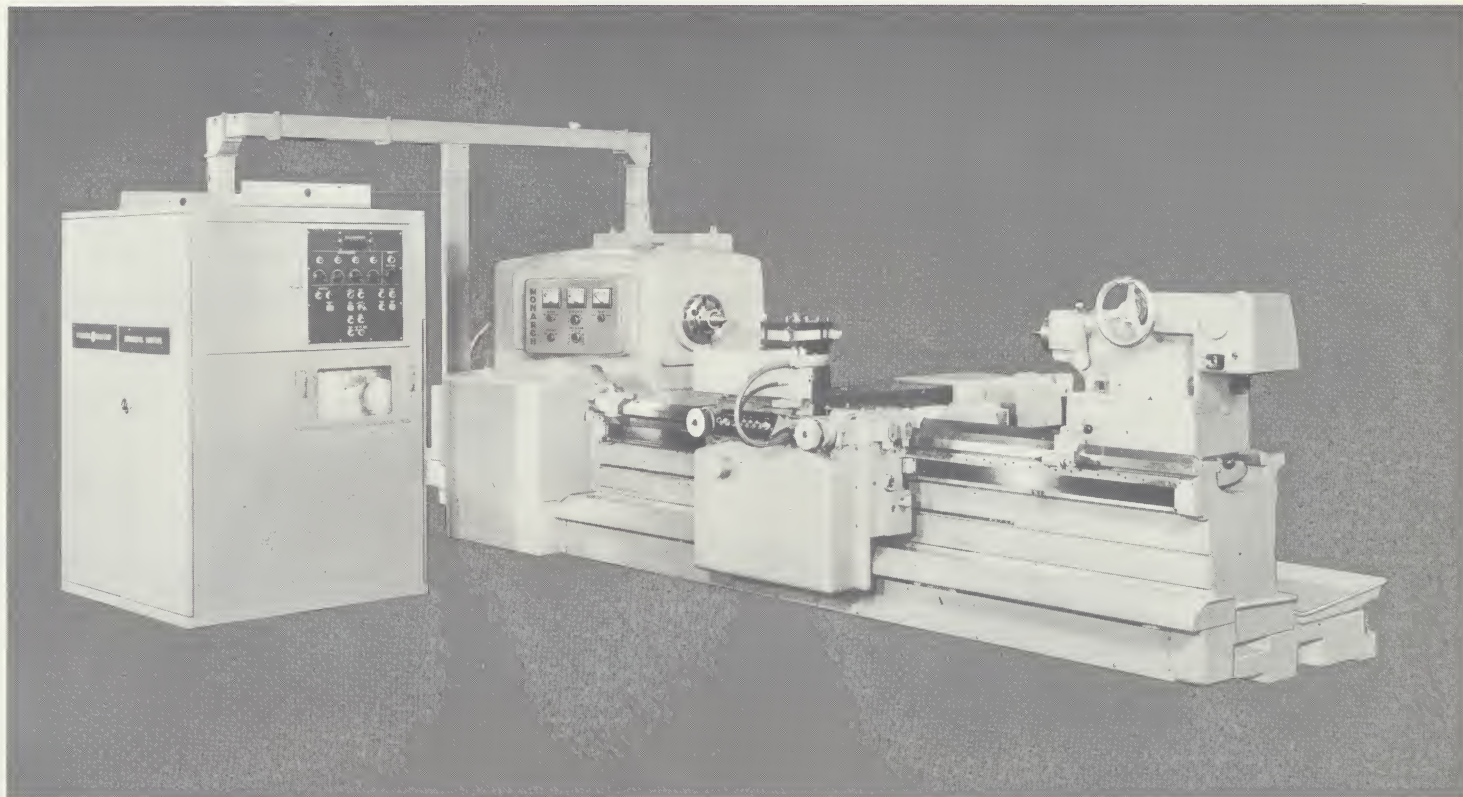
GENERAL  **ELECTRIC**

Another example of modernized machining

Monarch *Pathfinder* Lathes

with

General Electric Mark Century* Numerical Control



... custom engineered to meet specific job requirements

Designed to reduce turning costs and increase your profits, the Monarch Pathfinder lathe with G-E Mark Century numerical control provides a completely new concept in turning that will not only meet today's turning problems, but those of the future as well. In a variety of production jobs in which these lathes are now operating, savings of 50 to 85 percent over conventional methods have been realized. Tool costs have been substantially reduced and set-up time shortened.

The Monarch Pathfinder lathe/Mark Century control represents a proven design engineered to a high degree of reliability. The module construction of the control system and manifold hydraulic servo units provide the best combination of machine and control for optimum performance over long life.

The Mark Century control system employs solid-state components and plug-in, modular-type printed circuit boards. Automatic, semiautomatic and manual modes of operation enable the operator to change tools, check the work,

or manually operate the machine without losing synchronization. Manual insertion of data is done with data input selector switches located on the operator's panel.

The control system provides simultaneous control of the longitudinal (Z Axis) and transverse (X Axis) with both linear and circular interpolation. This permits manual programming of straight cuts, tapers, radii and complex contours without a computer. The tool path, distance and feed rate are continuously coordinated so as to produce a smooth contour as dictated by the numerical information. Turning, facing, boring and form cuts may be made in the same set-up.

Numerical data also controls feed rate, spindle speed, turret position, and auxiliary functions such as coolant on/off, feed over-ride and traverse. This allows programming of the proper cutting speeds and feeds for each individual tool in the turret.

Servo drives—Main drive to the longitudinal slide (Z Axis) is by a hy-

draulic motor through two pre-loaded pinions into a power rack. The feedback resolver is from a precision rack which carries no load. Power to the transverse slide (X Axis) is through a hydraulic cylinder. Again, the feedback resolver is driven by a precision ball screw which carries no load.

Feed Rate—Longitudinal slide (Z Axis)
Feed—0.01 to 40 inch/min.
Traverse—140 inch/min.
Transverse slide (X Axis)
Feed—0.01 to 48 inch/min.
Traverse—140 inch/min.

Turret—The heavy eight-position hydraulically indexing base allows for the use of pre-set turret body. The standard body consists of a 4-way turret body. A six-position turret is available for chucking work. The turret repeats positions within three seconds of arc for assured accuracy, and can approach to within 1 3/4 inch of the spindle nose, minimizing tool overhang.

* Trade-mark of General Electric Co.

THE PRODUCTS . . .

Sleeve Ring

This part was completed in two handlings.

First operation:

Face end and rough bore
Finish bore
Groove

Second operation:

Rough bore and face to length
Finish contour bore
Turn O.D.
Form face of counterbore
Part turned at 310 stpm using 0.016 ipr feed

Tolerance: Taper and groove held to special gages ± 0.0001 -inch limits.

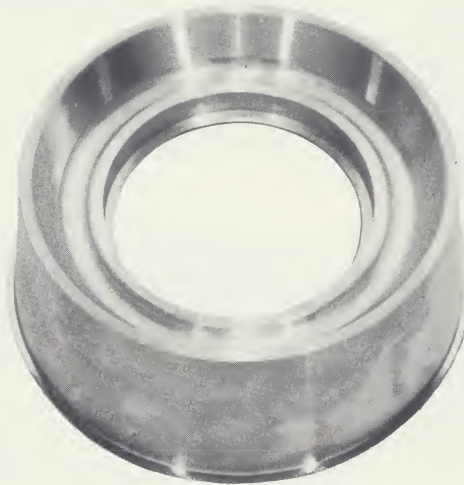
Time required:

First operation: 6.0 minutes
Second operation: 9.6 minutes

Time formerly required:

First operation: 35.4 minutes
Second operation: 57.7 minutes

Time savings ratio: 1 to 6



Rotor Shaft

This part was completed in one set-up before removal from lathe.

First operation:

Rough turn	350 stpm	0.020 ipr feed
Finish turn	400 stpm	0.015 feed
Groove	150 stpm	0.006 ipr feed
Thread	180 rpm	(1¼-12 thd.) 17 passes

Second Operation:

Rough turn	350 stpm	0.020 ipr feed
Finish turn	400 stpm	0.015 ipr feed
Groove	150 stpm	0.006 ipr feed
Thread	180 rpm	(1½-8) 12 passes

Tolerances:

0.020 grind stock left on diameter
Shoulder lengths held to within 0.003-inch

Time: 10.7 minutes

Former time: 45.1 minutes

Savings ratio: 1 to 4



Bearing Cap

This part is turned in one set-up using square turret; no grinding required.

Operation:

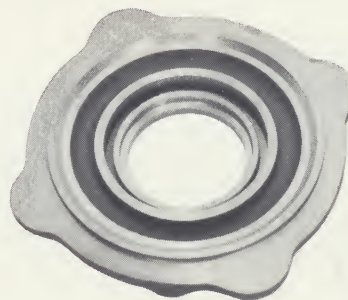
Rough turn and face	360 stpm	0.016 ipr feed
Counterface	360 stpm	0.016 ipr feed
Rough bore	360 stpm	0.013 ipr feed
Finish face	360 stpm	0.011 ipr feed
Groove	180 stpm	0.0045 ipr feed
Chamfer	360 stpm	
Finish turn O.D.	400 stpm	0.007 ipr feed

Tolerance: Face and hub held to within 0.001-inch

Time: 5.9 minutes

Former time: 23.6 minutes

Savings ratio: 1 to 4



For more information on the Monarch Pathfinder numerically controlled lathes, see your Monarch representative, or write to The Monarch Machine Tool Company, Sidney, Ohio.



Mark Century

For descriptive information on G-E Mark Century numerical contouring and positioning control systems, write for Bulletin GEA-7590, Distribution Services, General Electric Company, Schenectady, N. Y.

GENERAL  ELECTRIC

LELAND-GIFFORD

Printed Circuit Board Drilling Machines

with General Electric Mark Century* Numerical Control

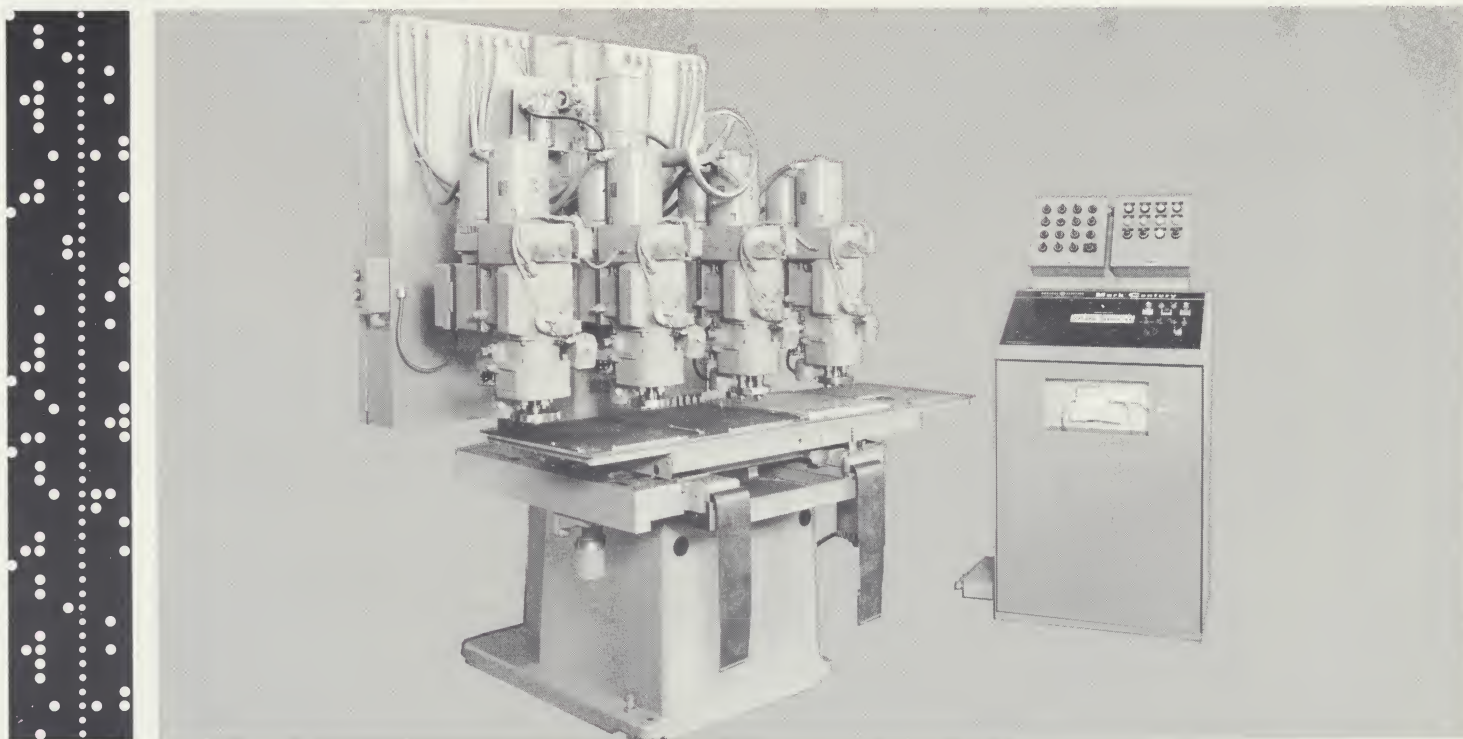
*Trademark of General Electric Company

... for automatic drill changing

FEATURES

- Four drills on each of four turrets allow continuous operation.
- Accurate speed control permits stacked drilling for large quantity operation.
- Oil-mist lubrication system assures long, trouble-free production.
- DC servo-regulated spindles produce burr-free holes.
- Conveniently located control console permits set-up and operation without wasted motion.
- Spindle-drive motor options produce greater flexibility.
- Micrometer-graduated handwheel and dovetail slide permit precision height adjustment.
- Self-contained hydraulic-feed drilling unit has a four-inch stroke with ample thrust for $\frac{3}{16}$ " drills from 500 rpm to 12,000 rpm and up to 20,000 rpm with turret.
- Operating spindle in forward turret position eliminates need to program offset (with turret).
- All units are interlocked so drills cannot feed until table and drill are in position.
- Spring-loaded pressure foot keeps boards flat, assures no pickup, and minimizes breakout.
- Guide bushings prevent drill wander and whip.
- Each axis of table positions simultaneously and independently by separate drill-ball lead screws.

Another example of modernized machining



DESCRIPTION

The LELAND-GIFFORD printed circuit board drilling machine, equipped with General Electric Mark Century numerical control, is an automatic, multiple-operation machining center designed for either small or large lot drilling of printed circuit boards.

The LELAND-GIFFORD machine has four turrets, each containing four drilling spindles. Drill sizes can be selected automatically and spindle speed can be adjusted automatically by tape command. For finishing work, the spindles can be fitted with special tools to rout, square off and clean board edges. This reduces handling and increases machine efficiency.

For large quantity production runs, boards can be stacked under each turret as high as four $\frac{1}{8}$ " boards or seven $\frac{1}{16}$ " boards.

Spindles are DC servo regulated for accurate, continuous speed. This results in clean, perfectly drilled holes with no burrs or tears—even under stack-drilling conditions.

The General Electric Mark Century 120 numerical control accepts standard one-inch, 8-channel punched tape. Or, data may be added by manual data-input switches on the control panel. Programming is simple and can be handled by anyone familiar with LELAND-GIFFORD machines.

N/C FUNCTIONS

- Two-axis simultaneous control with maximum command of 99.9999" for each axis.
- Minimum input dimension is 0.0001".
- Standard $\frac{1}{2}$ hp servo drives operate at positioning speeds up to 300 ipm.
- Zero offset enables quick location of zero point.
- Three modes of operation — automatic, semi-automatic or manual.
- Full range of auxiliary operations available.

Specifications

Table size 17" x 44" (2 unit machine)
22" x 44" (2 unit machine)
17" x 70" (4 unit machine)
22" x 70" (4 unit machine)

Table travel 16" x 12"
or
16" x 20"

Spindle travel 4 $\frac{3}{8}$ "

Spindle travel with turret 3 $\frac{1}{4}$ "

Vertical adjustment of rail 7"

Chuck nose to table distance 0" min. to 7" max.

Spindle speed range with single unit (change gears)
500 rpm min. to 12,000 rpm max.

Spindle speed range with turret unit (change gears)
500 rpm min. to 20,000 rpm max.

Spindle speed range with DC variable speed drive
(10 to 1 ratio) 500 rpm min. to 20,000 rpm max.

Single speed motor (spindle & hydraulic pump) 3 $\frac{1}{4}$ hp

Variable speed motor 1 $\frac{1}{3}$ hp

Feed rate — infinitely variable 0-80 ipm

Feed positive hydraulic

Tape controlled turret index.

Automatic spindle speed variations when using the turret
and DC variable speed motor.

Combination pressure foot and drill-guide bushing.



LELAND-GIFFORD
MACHINE TOOLS

5-67 (17M)

For more information on LELAND-GIFFORD machine tools, write to LELAND-GIFFORD, Worcester, Massachusetts 01601.

Mark
Century
GENERAL ELECTRIC

For descriptive information on General Electric numerical control systems, write for N/C Data File, GEZ-3774, Distribution Services, General Electric Company, Schenectady, N. Y. 12305.

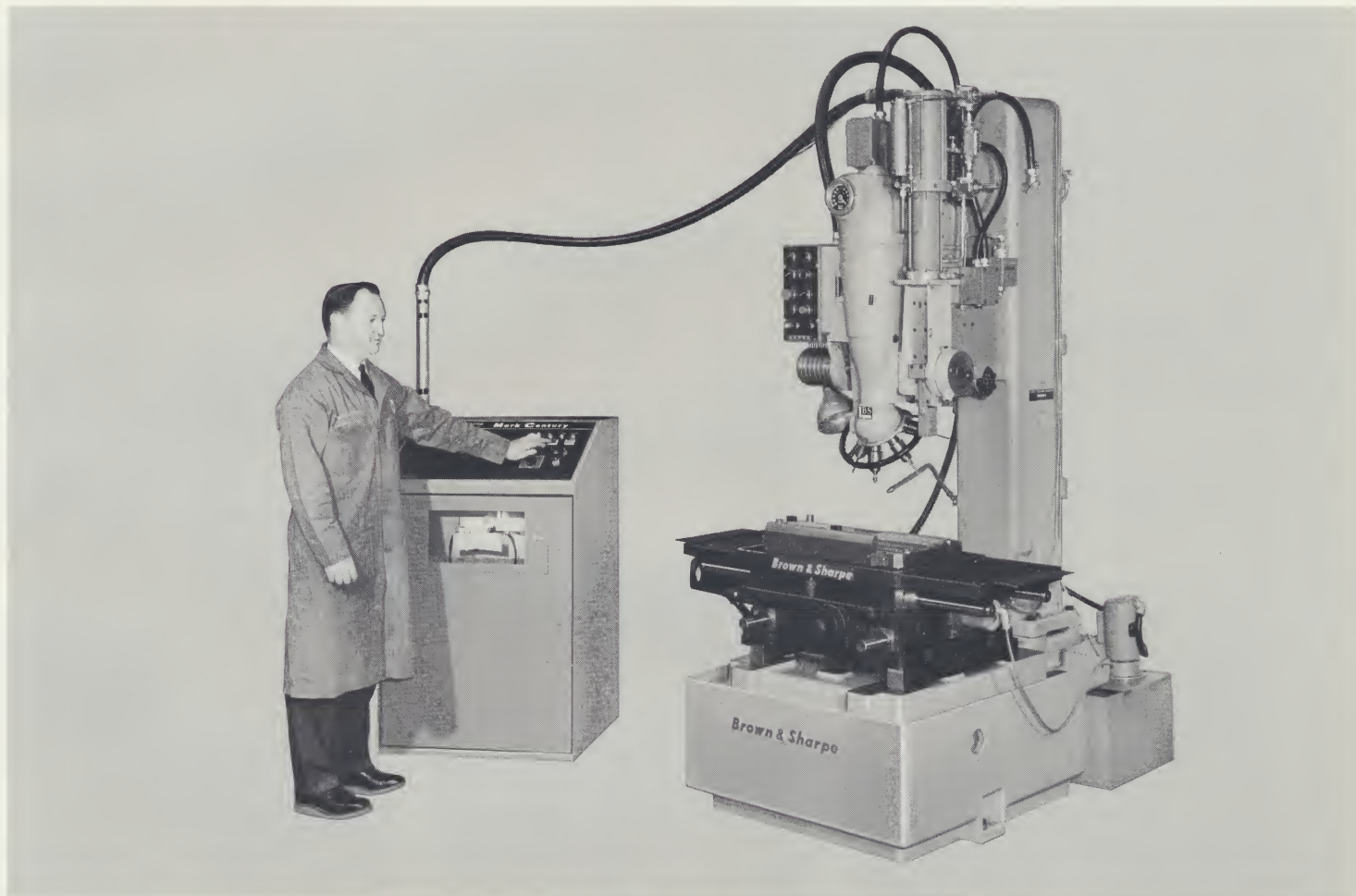
Another example of modernized machining

Brown & Sharpe TURR-E-TAPE AB-1118

with

General Electric Mark Century* 120 Numerical Control

*Reg. trade-mark of General Electric Co.



...for accurate and economic drilling, tapping, reaming and counterboring.

FEATURES

- Six drills on self-aligning spindles
- Drill speed range of 200 rpm to 4000 rpm on each spindle
- Electrical tapping on all spindles without added tapping heads
- Integrated operation of positioning table and machine tool
- Absolute work-table positioning
- Ample capacity for machining large pieces
- Sturdy construction for continuous operation under heavy work loads

DESCRIPTION

Brown and Sharpe TURR-E-TAPE AB-1118 turret drilling machine with General Electric Mark Century 120 numerical positioning control performs drilling, tapping, reaming and counterboring operations accurately and economically.

Turret indexing is controlled by tape, while the automatic tool feed is controlled electrically. In operation, each spindle has a variable speed range of 200 rpm to 4000 rpm and can tap directly without the need for added tapping heads. Time-consuming drill changes are not required, thus production is speeded.

Tape control automatically guides

work-table positioning simultaneously. All references are made to a fixed zero point to assure accuracy with any hole pattern. A simple work-holding device is the only tooling necessary even for large pieces, eliminating expensive jigs and fixtures.

TAPE CONTROL FUNCTIONS

- Simultaneous longitudinal and cross travel of table throughout any sequence, to any point
- Absolute programming—all references made to single zero point (EIA standard).
- Table always approaches next position in same direction to eliminate backlash or wind up errors

SPECIFICATIONS

Turret Drilling Machine

Turret spindles 6 (with #33 Male J. T.)
 Drilling capacity 1/2"
 Tap capacity 1/2"
 Quill travel 6 1/2"
 Spindle speeds 200 rpm to 4000 rpm variable
 on each spindle
 Spindle motor 1 hp, 2-speed (1800 rpm—900 rpm)
 220 V or 440 V—60 cycle, 3 phase
 Air . . self-contained air pressure regulator, cleaner and oiler
 Depth control . . pre-selective, within 0.002" on each spindle
 Head travel 18" (vertical)

Max. clearance (#33 Male J.T. spindle to table) . . . 25 7/8"
 Throat clearance 22 1/2"
 Net weight (machine, table and control system) . . 3400 lbs.
 (approx.)
 Closed height 90 1/4"
 Extended height 105"
 Floor space including control 120" wide—65" deep

Positioning Table

Table travel 11" x 18"
 Table work surface 13" x 22"
 Positioning motors (2) 1/2 hp Thymotrol* d-c
 Positioning speed 200 ipm

*Reg. trade-mark of General Electric Co.

THE PRODUCTS . . .

Aircraft instrument plates

Tooling costs were cut 89 percent for these aircraft instrument mechanism plates. Jig and fixture costs formerly averaged \$360 per job. Now they are only \$40 using the B&S TURR-E-TAPE and G-E Mark Century 120 n/c.

Aluminum sign base parts

A drilling job that formerly required 13 hours for this part now requires only five hours with the TURR-E-TAPE and G-E Mark Century 120 n/c. Tool preparation time has also been reduced from seven to one-and-a-half hours.

Textile machine parts

Jig expense for these parts has been practically eliminated by the TURR-E-TAPE with G-E Mark Century 120 n/c. Savings run from \$150-\$200 per job. Total plant savings for jigs are averaging \$1500 per month.



For information on B&S AB-1118 and other Turret Drilling Machines, write to Brown & Sharpe Mfg. Co., Providence 1, R. I.



Brown & Sharpe

Mark
Century

For descriptive information on G-E numerical control systems, write for bulletins N/C Data File, GEZ-3774, Distribution Services, General Electric Company, Schenectady, N.Y.

GENERAL  ELECTRIC

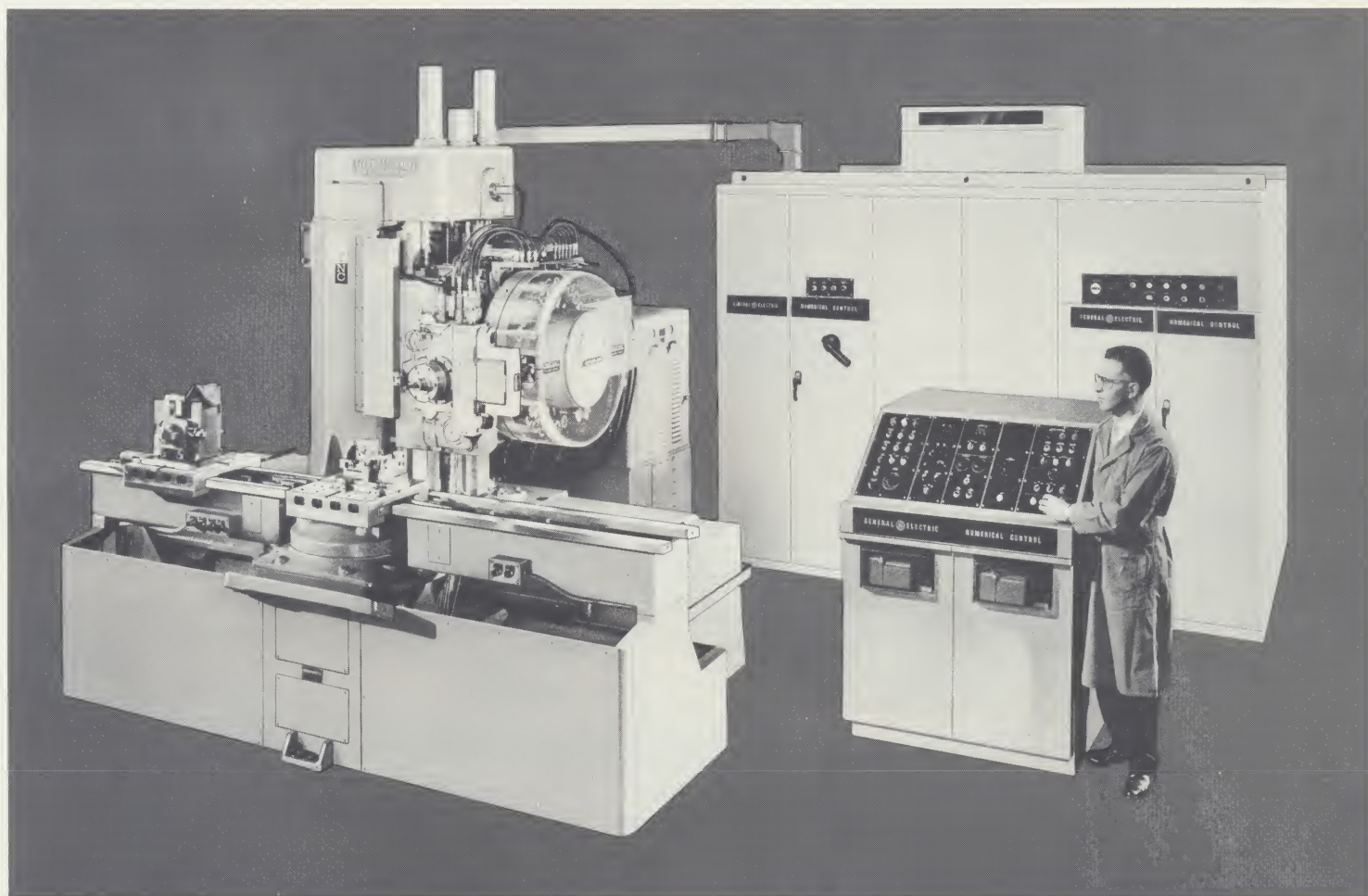
Another example of modernized machining

Kearney & Trecker Model II, 3-axis Milwaukee-Matic

with

General Electric Mark Century* Numerical Control

*Trade-mark of General Electric Co.



... for fully automatic milling, drilling, reaming, tapping and boring operations.

FEATURES

- Exclusive automatic tool changer
- 31-tool capacity
- Table indexing for 360-degree part access
- Dual-system absolute positioning and precision contouring control or single-system precision absolute positioning control

DESCRIPTION

The Kearney & Trecker Model II, 3-axis Milwaukee-Matic, equipped with General Electric Mark Century Numerical Control, is a fully automatic production center capable of performing milling,

drilling, reaming, tapping and boring operations in any sequence, on several sides of a work piece with a single setup.

Thirty tools can be accommodated in the rotary magazine while one tool is active in the spindle. Within eight seconds, the tool changer automatically removes the used tool and returns it to the magazine, simultaneously inserting a new tool into the spindle.

The standard table can index directly to any of eight 45-degree positions, providing 360-degree access to the part being machined.

A pallet shuttle accessory provides for automatic reciprocal operation between

two pallets. Loading, set-up, and part changes are performed while the machine is producing to eliminate machine down-time.

Fully automatic operation with tape control assures quality regardless of operator skill.

CONTROL FUNCTIONS

- Combined-system absolute positioning and precision contouring
- Single-system absolute positioning
- Automatic tool selection and changing, table indexing, pallet transfer, coolant, spindle speeds, and axis feed rates

SPECIFICATIONS

Slide movements:

column—longitudinal (X axis) 24 in.
spindle head—vertical (Y axis) 20 in.
spindle head—depth (Z axis) 16 in.

Pallet work surface 18 in. x 18 in.

8-position index table (standard) 360 degrees
in 45-degree increments

360,000-position index table (optional) 360 degrees
in 0.001-degree increments

POSITIONING FEED RATES (Single and dual systems)

All linear axes 0.5 ipm to 50 ipm

Rapid traverse 150 ipm

Steps	Range
0.1 ipm	0.5 to 9.9
0.1 ipm	10 to 50

Programmed feed rate over-ride 100% to 50%
in 10% steps (controlled from operator's console)

CONTOURING FEED RATES (Dual systems only)

Variable rates from 0.1 in. to 50 in. per minute
(by means of coded feed rate numbers)

Programmed feed rate over-ride 100% to 0%
in 10% steps

SPINDLE SPEEDS AND HORSEPOWER

Range	Speeds	Horsepower*
1	100 to 590	2 1/2 to 10
2	600 to 1590	4 to 10
3	1600 to 4000	4 to 10

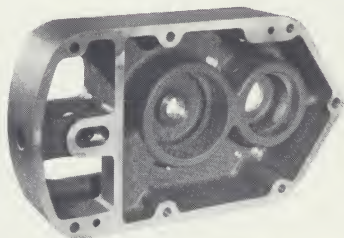
*Horsepower varies with spindle speed through three ranges which are automatically selected by means of electric disc-type clutches

Tape reading speed 20 characters per second

Tape format binary coded decimal-tab sequential
—1-in. wide, 8-channel

Control system resolution 0.0001 in.
Controls are air conditioned to operate in 122 F ambient

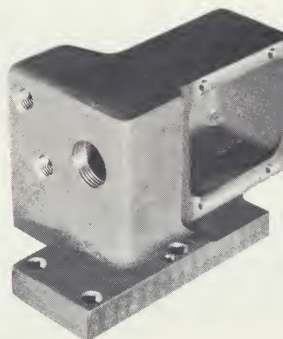
THE PRODUCTS . . .



Motor Base

Material . . . aluminum
Lot size 15

	Conven- tional	Milwaukee- Matic
Setup	4.48 hrs	none
Cycle	1.86 hrs	.65 hrs
Tooling	\$2350	\$835



Feed Control Switch Box

Material 326 aluminum
casting
Lot size 10

	Conven- tional	Milwaukee- Matic
Setup	2.99 hrs	none
Cycle	.63 hrs	.41 hrs 2 operations
Tooling	\$475.00	none*

*Universal tooling used

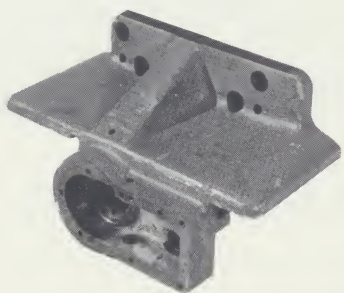
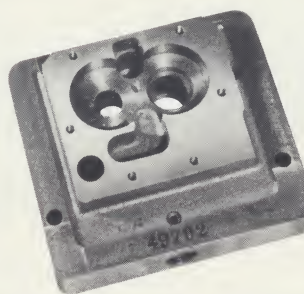


Table Bracket

Material . . . cast iron
Lot size 10

	Conven- tional	Milwaukee- Matic
Setup	11.44 hrs	none
Cycle	2.64 hrs	.7 hrs
Tooling	\$4700	\$1900



Coolant Pump Body

Material . . . C1-B-35
Lot size 20

	Conven- tional	Milwaukee- Matic
Setup	3.80 hrs	none
Cycle	2.45 hrs	1.4 hrs
Tooling	\$775.00	none*

*Universal tooling used



For more information on Milwaukee-Matic machine tools, write to Kearney & Trecker Corporation, Milwaukee Wisconsin, 53214

KEARNEY & TRECKER CORPORATION

Mark Century

For descriptive information on General Electric numerical control systems, write for Bulletin GEA-7590, Distribution Services, General Electric Company, Schenectady, New York

GENERAL  ELECTRIC

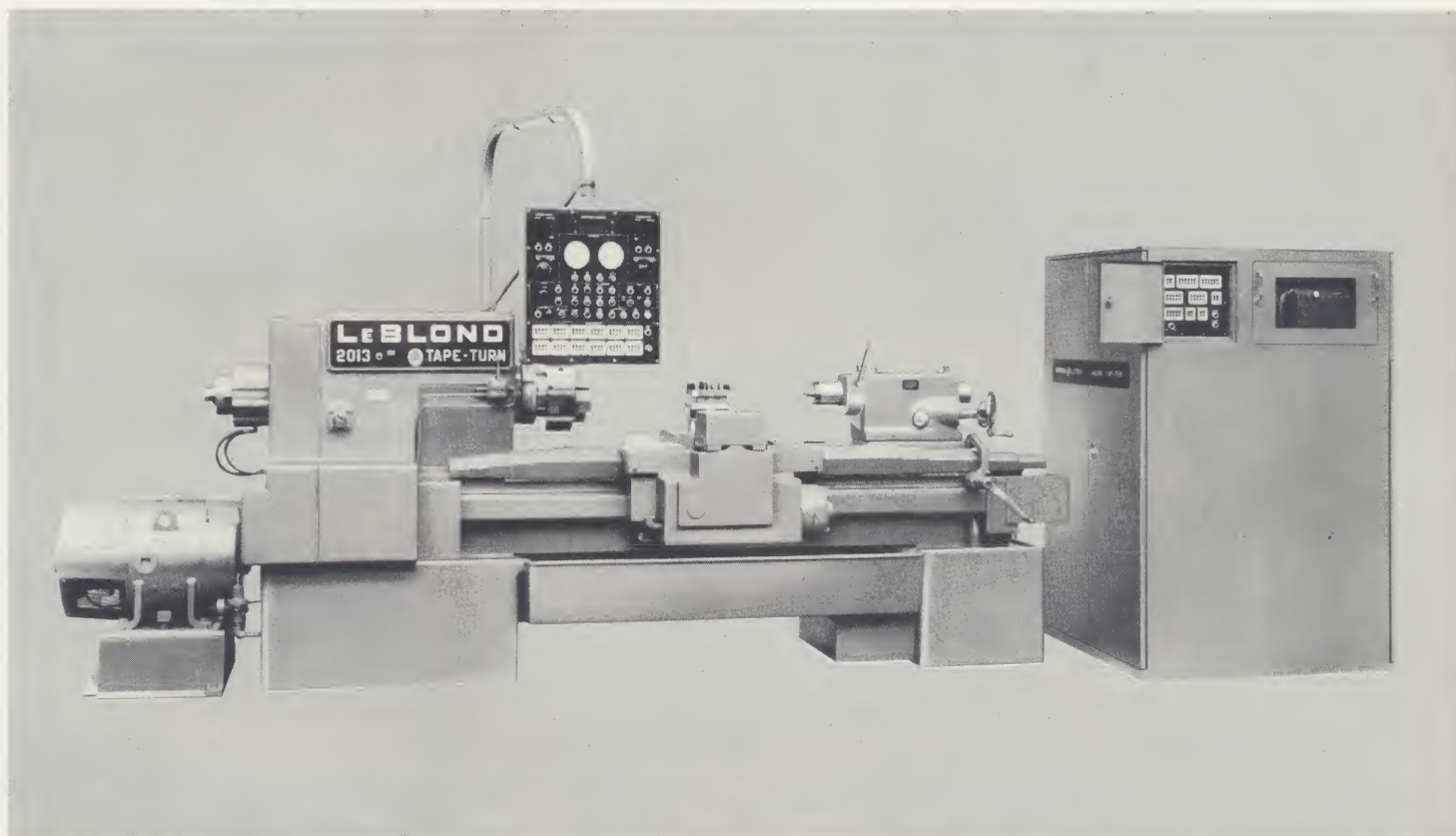
Another example of modernized machining

LeBLOND 2013NE TAPE-TURN Lathe

with

General Electric Mark Century* Numerical Control

*Trade-mark of General Electric Company



... for all continuous-path turning operations.

FEATURES

- Complete tape-controlled lathe capability
- Constructed for constant heavy-duty operation
- Numerical control of major machine functions

DESCRIPTION

The LeBlond 2013NE TAPE-TURN lathe with General Electric Mark Century Numerical Control turns steps, slopes, radii, complex curves, shoulders, tapers, grooves, faces and threads. It turns toward or away from the headstock, and inside as well as outside contours. The TAPE-TURN 2013 also bores, cuts off, knurls and cuts threads with constant or changing leads.

Heavy-duty construction permits constant, round-the-clock operation under

the heaviest work loads. Wide, heavy beds utilize cross girths in a modified bridge-truss design to resist bending and torsional forces built up during cutting. The tailstock is designed with a large barrel to absorb the load of heavy pieces. A unique worm and rack arrangement assures good spindle travel and firm support even when the spindle is fully extended.

The TAPE-TURN 2013 carriage is built with a great amount of bearing surface on the ways, resulting in less wear, greater accuracy, and positive alignment during all cutting operations. The long inner-way surface permits smooth feeding under the heaviest cuts without any tendency to climb or cramp.

Turret tool-holders make possible use of a variety of tools for cutting. The automatic turret-indexing mechanism

allows selection of five possible tool-cutting positions.

All major machine functions are carried out in desired speeds and feeds through automatic tape control.

NUMERICAL CONTROL FUNCTIONS

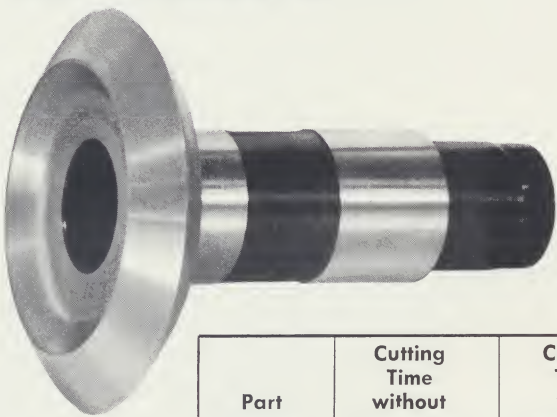
- Guides cut along straight lines, in parallel to Z or X axes, at any angle to them, or in clockwise or counter-clockwise arcs
- Controls feeds, speeds, tool-turret positioning, and slope functions for determining angular movement
- Commands Servo-Shift gear train in headstock, giving total of 180 spindle speeds
- Directs tool movement toward headstock or tailstock and in and out
- Cuts threads by electrical integration

- Repeat electrical positioning accuracy of 0.0002" with a system resolution of 0.0001"
- Zero offset over the full range of travel
- Manual control allows override of tape; operator can perform any operation that can be done by tape from console or pendant station
- GECENT postprocessor available for use with APT III computer language

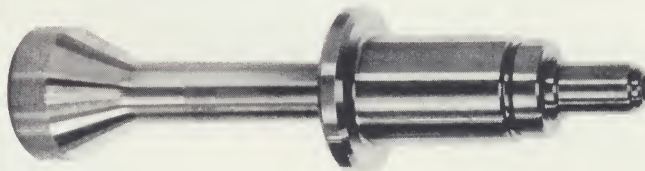
GENERAL CAPACITY SPECIFICATIONS

Swing over bed and carriage wings	25"
Swing over cross slide	13"
Standard center distances	54", 78", 102", and 126"
Steady rest capacity, min and max dia, std size	3/4" to 8 1/2"
Steady rest capacity, min and max dia, oversize	8 1/2" to 13"
Face-plate dia, small (standard equipment)	10"
Face-plate dia, large (extra equipment)	19 1/2"
Distance, spindle-center to floor	44 3/4"

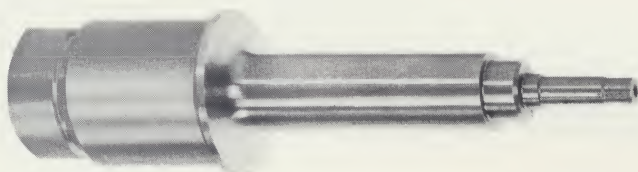
THE PRODUCTS . . .



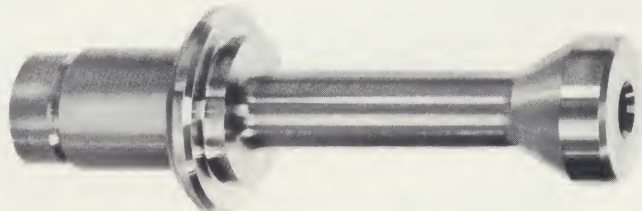
Part Number	Cutting Time without Numerical Control	Cutting Time with Numerical Control
514D288	27 minutes	9 minutes



Part Number	Cutting Time without Numerical Control	Cutting Time with Numerical Control
639E515	46 minutes	19 minutes



Part Number	Cutting Time without Numerical Control	Cutting Time with Numerical Control
516D837	16 minutes	8 minutes



Part Number	Cutting Time without Numerical Control	Cutting Time with Numerical Control
516D910	33 minutes	11 minutes



For more information on TAPE-TURN lathes, write to the R. K. LeBlond Machine Tool Company, Madison at Edwards Road, Cincinnati, Ohio 45208.

THE R. K. LeBLOND MACHINE TOOL COMPANY

Mark Century

For descriptive information on General Electric numerical control systems, write for Bulletin GEA-7590, Distribution Services, General Electric Company, Schenectady, New York.

GENERAL  ELECTRIC

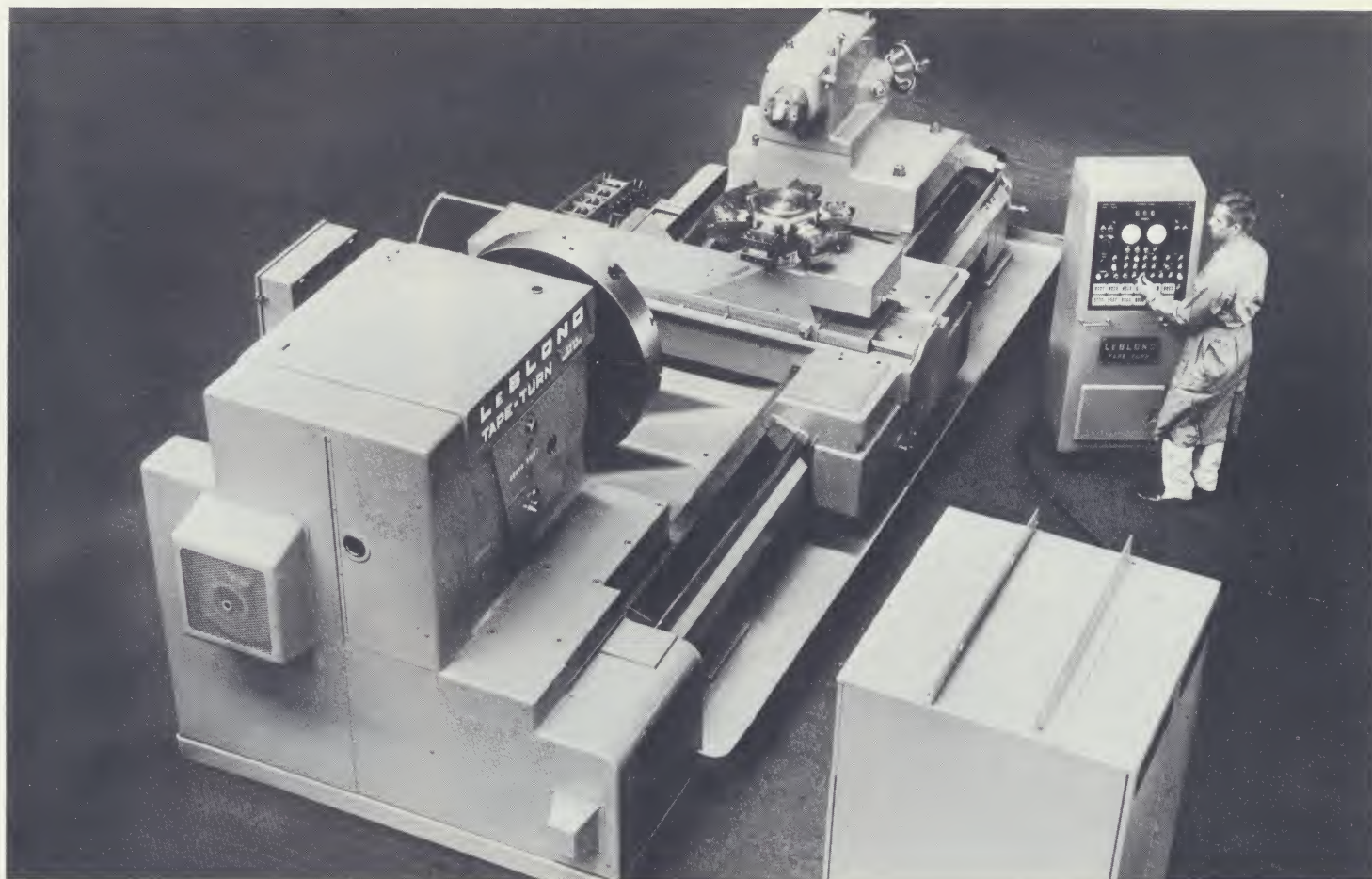
Another example of modernized machining

LEBLOND 6036 Tape-Turn Lathe

with

General Electric Mark Century* Numerical Control

*Trade-mark of General Electric Co.



Heavy-duty lathe provides fast, accurate tape turning of complex parts

FEATURES

- Special 36-speed Servo-Shift tape
- Completely tape-controlled lathe capability
- Constructed for constant, heavy-duty operation
- Numerical control of major machine functions

DESCRIPTION

The LeBlond 6036 Tape-Turn lathe is equipped with a six-station, 12-position turret, and General Electric Mark Century numerical contouring control with buffer readout. This lathe can turn, bore, face, or thread, and in one application, produces complex parts for one of the nation's large missiles.

The 75-horsepower headstock has 36 speeds that are servo-shifted by tape command. This drive, coupled with extra-heavy bridge design, gives the lathe a tremendous metal-removal rate (roughing and finishing cutting speeds were held between 200 and 300 sfpm).

Even with the mass of this lathe, the LeBlond method of ball-screw compensation allows the movement of the carriage and cross slide to within close limits. Smooth machine operation is further achieved by long carriage wings, a 15-inch-diameter curvic coupling beneath the turret, and a heavily ribbed bed.

The missile component machined on this lathe is made from a stainless-steel forging 25" in diameter and 6" thick.

Selected tooling is the replaceable-

insert variety, while the finish tools are the ultra-precision type ($\pm 0.0005''$ tolerance). The grooving operations are done with two special tools, specifically designed for those operations.

To program this part, APT computerized programming was used. Due to the complex geometry of the workpiece, it was necessary to break the program down into five parts and use the APT III system for three of these parts. The length of the punched tape for all five parts of the program is approximately 1500 feet.

One of the greatest advantages to using numerical control, in addition to tooling and setup-time savings, is elimination of the time-consuming, light-cut-and-try procedure which would be necessary with conventional machining.

NUMERICAL CONTROL FUNCTIONS

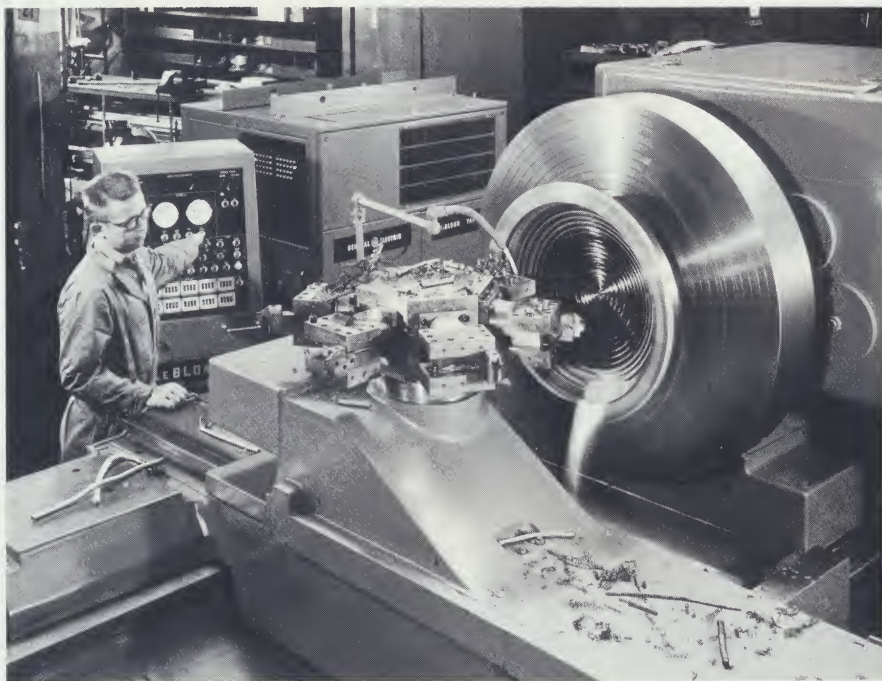
- Guides cut along straight lines, in parallel to Z or X axes, at any angle to them, or in clockwise or counter-clockwise arcs.
- Controls feeds, speeds, tool-turret positioning, and slope functions for determining angular movement.
- Commands Servo-Shift gear train in headstock, giving a total of 180 spindle speeds.
- Directs tool movement toward headstock or tailstock and in and out.

GENERAL CAPACITY SPECIFICATIONS

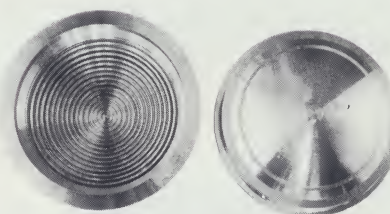
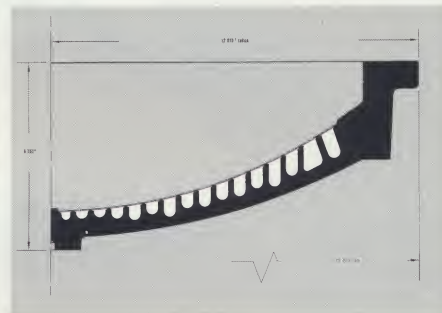
Swing over bed and carriage wings	60"
Swing over cross slide	36"
Basic center distance	66"
Face plate dia., small (standard equipment)	36"
Distance, spindle-center to floor	58"

- Cuts threads by electrical integration.
- Repeat electrical positioning accuracy of 0.0002" with a system resolution of 0.0001".
- Zero offset over the full range of travel.
- Manual control allows override of tape; operator can duplicate any operation that can be done by tape from console or pendant station.
- GECENT postprocessor is available for use with APT III computer language.

THE PRODUCT . . .



Complex shape of this missile part is turned on LeBlond's heavy-duty 6036 Tape-Turn Lathe to exacting specifications. Guided by General Electric numerical control, the lathe reduced the time required for most operations by approximately five to one.



Missile component, similar to a boiler head, is machined from a work-hardening stainless-steel forging 25" in diameter by 6" thick. It contains a series of closely spaced annular grooves.



For more information on Tape-Turn lathes, write to the R. K. LeBlond Machine Tool Company, Madison at Edwards Road, Cincinnati, Ohio 45208.

THE R. K. LeBLOND MACHINE TOOL COMPANY

Mark Century

For descriptive information on General Electric numerical control systems, write for Bulletin GEZ-3774, Distribution Services, General Electric Company, Schenectady, New York.

GENERAL  ELECTRIC

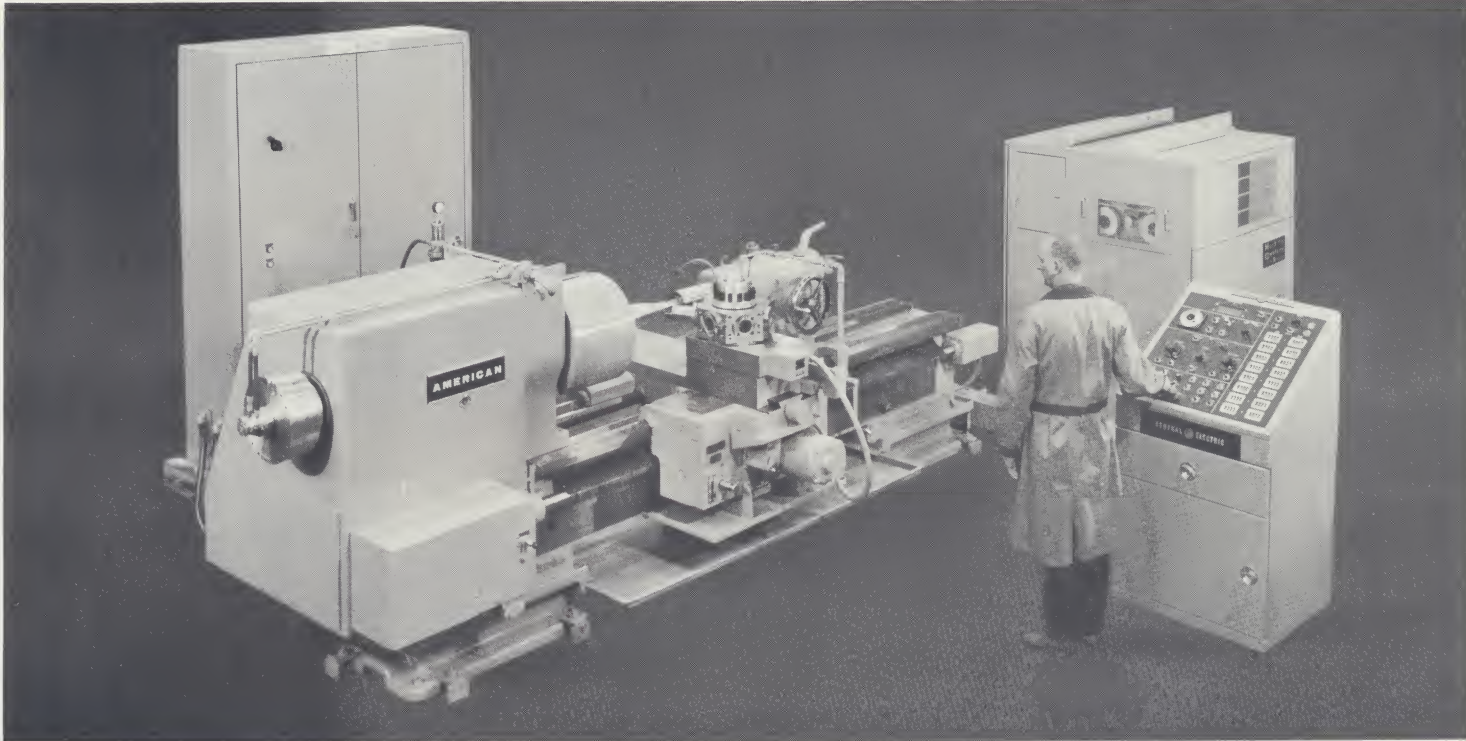
Another example of modernized machining

AMERICAN TAPE-CONTROLLED LATHE

With Minuteman Coordinate Set-Up and

General Electric Mark Century* Numerical Control

*Trade Mark of General Electric Co.



... a new "STRESS FREE" fixturing concept,
new tooling, computerized programming, the systems approach to a parts family.

FEATURES

- Designed with a special turret to resist deflection when boring.
- Holds a fragile part requiring precision tolerance relatively "STRESS FREE."
- Systems approach to program a family of parts.
- Massive, rugged construction for heavy-duty operation, yet maintains precision tolerances for either the big or small job.
- Coolant manifold brings out the coolant at tool point.
- Fast zero setting with Minuteman coordinate set-up.
- Continuous path tapers and radii.
- Simple tape preparation.
- Pre-set interchangeable turret tool holder.
- Constant chip thickness, automatic.
- Anti-friction tailstock spindle center.

- Three-bearing support of headstock spindle.
- Size range from 2413 to 7050.
- Feed override.
- Manual data input.
- Main bearings adjusted simultaneously from outside the headstock.
- Zero offsets for turret tool holder.
- Jog-traverse pushbutton selector switch for lathe axes.

DESCRIPTION

The American Tape-controlled Lathe with Minuteman Coordinate Set-Up and General Electric Mark Century numerical control provides fully automatic turning, facing, boring and form tooling, and handles roughing as well as finishing with equal ease.

Set-up time is reduced drastically with the American Minuteman Coordinate system. The interchangeable turret

tool holder, either square or hexagonal, is pre-set with accurate pre-setting tools, and is quickly mounted on a curvic coupling. A single nut holds it in place. By console dial, the carriage is positioned at X and Y 'zero' positions. Limit switches maintain these 'zero' positions until you change them. Just switch to automatic, push the button, and let the tape make the part. That's all there is to it, and your American lathe is 'zeroed in' until you change it.

NUMERICAL CONTROL FUNCTIONS

- Tool path contour
- Feed rate
- Cutting-tool selection (turret index)
- Headstock spindle speed
- Forward, reverse of spindle
- Cutting-tool cycling
- Coolant on-off
- Feed dwell from 0 to 100 seconds

SPECIFICATIONS

SIZES	2413	2514	3220	3220W	4025W	4025	5035	6040	7050
Swing-Over Carriage Wing	25"	25"	32"	33½"	38"	40"	50"	60"	70"
Swing-Over Cross Slide	14"	14"	21"	22"	25"	25"	35"	40"	50"
Base Length Between Centers	54"	48"	48"	48"	48"	60"	60"	60"	60"
Main Drive, 32 to 1 Variable Speed Motor, H.P.	25	20-50	20-50	20-50	20-50	40-75	40-75	40-75	40-75
Taper of Center, Morse Taper Number	4	5	5	6	6	6	6	6	6
Number of Spindle Speed Points	40	60	60	60	60	60	60	60	60
Non-overlapping Spindle Speed Points	30	42	42	42	42	42	42	42	42
Range of Spindle Speeds, R.P.M.	27-2000	8-1200	8-1200	8-1200	8-1200	4-600	4-600	2-300	2-300
Length of Carriage on Bed	35"	35"	35"	40"	40"	49"	49"	54"	54"
Number of Feeds (Cross & Long.)	2000	2000	2000	2000	2000	2000	2000	2000	2000
Range of Feeds, Inches per Minute	0.1" to 20"	0.1" to 20"	0.01" to 20"	0.01" to 20"	0.1" to 20"	0.01" to 20"	0.01" to 20"	0.01" to 20"	0.01" to 20"
Minimum Increment of Feed, Inches per Min.	0.1"	0.01"	0.01"	0.01"	0.1"	0.01"	0.01"	0.01"	0.01"
Tool Turret (Square & Hex.) Across Face	8"	8"	8"	10"	10"	12½"	12½"	12½"	12½"
Size of Tool — Width & Height	1" x 1½"	1" x 1½"	1" x 1½"	1½" x 1½"	1½" x 1½"	2" x 2"	2" x 2"	2" x 2"	2" x 2"

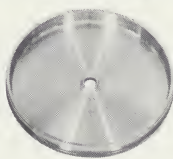
THE PRODUCTS . . .

Aluminum (T-4)



Piece is machined from 19" length and 7" diameter piece of T-4 aluminum. Rough cut 0.625" depth of cut at 450-1000 SFM with 0.0125" IPR. Cycle time—93 minutes.

Turbine Wheel for Jet Engine



Material is AMS 5613, 32-36 Rc. Rough turned at 300 SFM, 0.015" IPR with 0.312" depth of cut. Finished at 500 SFM, 0.005" IPR, with 0.0125" depth of cut. Cycle time—9 minutes.

Rock Bit



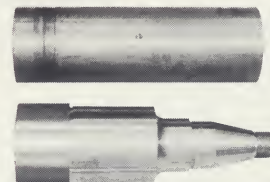
Material is 41-40 SAE, 38 Rc when turned. Machined at 520 SFM, with 0.003" to 0.010" IPR, and a 0.015" to 0.020" depth of cut, the cycle time is 9 minutes for both I.D. and O.D. It was previously turned on a Tracer Lathe with a minimum cycle time of 60 minutes. While the Tracer averaged only two parts per set of tools, on the Tape Lathe the average is now four per set of tools.

Test Piece



Material steel SAE 1045, 216 BHN. Two set-ups, threaded-end cycle time 25 minutes, second end 53 minutes. Rough turning was at 250 SFM, 0.020" IPR with ½" depth of cut. Finish turned at 500 SFM, 0.005" IPR. Threads 4 pitch (4" dia.) by 4½" length and second thread 3½" dia. by 11½" length at 25 SFM, .015" depth of cut each pass.

ATW Test Shaft



Material 1045 steel and hardness of 205-225 BHN. Weight of shaft at start 250 lbs. Removed 100 lbs. of metal in 18 minutes. Rough turned at 300 SFM, 0.028" IPR with ⅝" depth of cut. Finished at 400 SFM, 0.010" IPR and 0.0625" depth of cut. Cycle time—18 minutes.

AMERICAN

For more information on the American Tape-controlled Lathe, write to the American Tool Works Co., Pearl and Eggleston Ave., Cincinnati, Ohio.

THE AMERICAN TOOL WORKS COMPANY

Mark Century

For descriptive information on General Electric numerical control systems, write for N/C Data File, GEZ-3774A, Distribution Services, General Electric Company, Schenectady, N. Y.

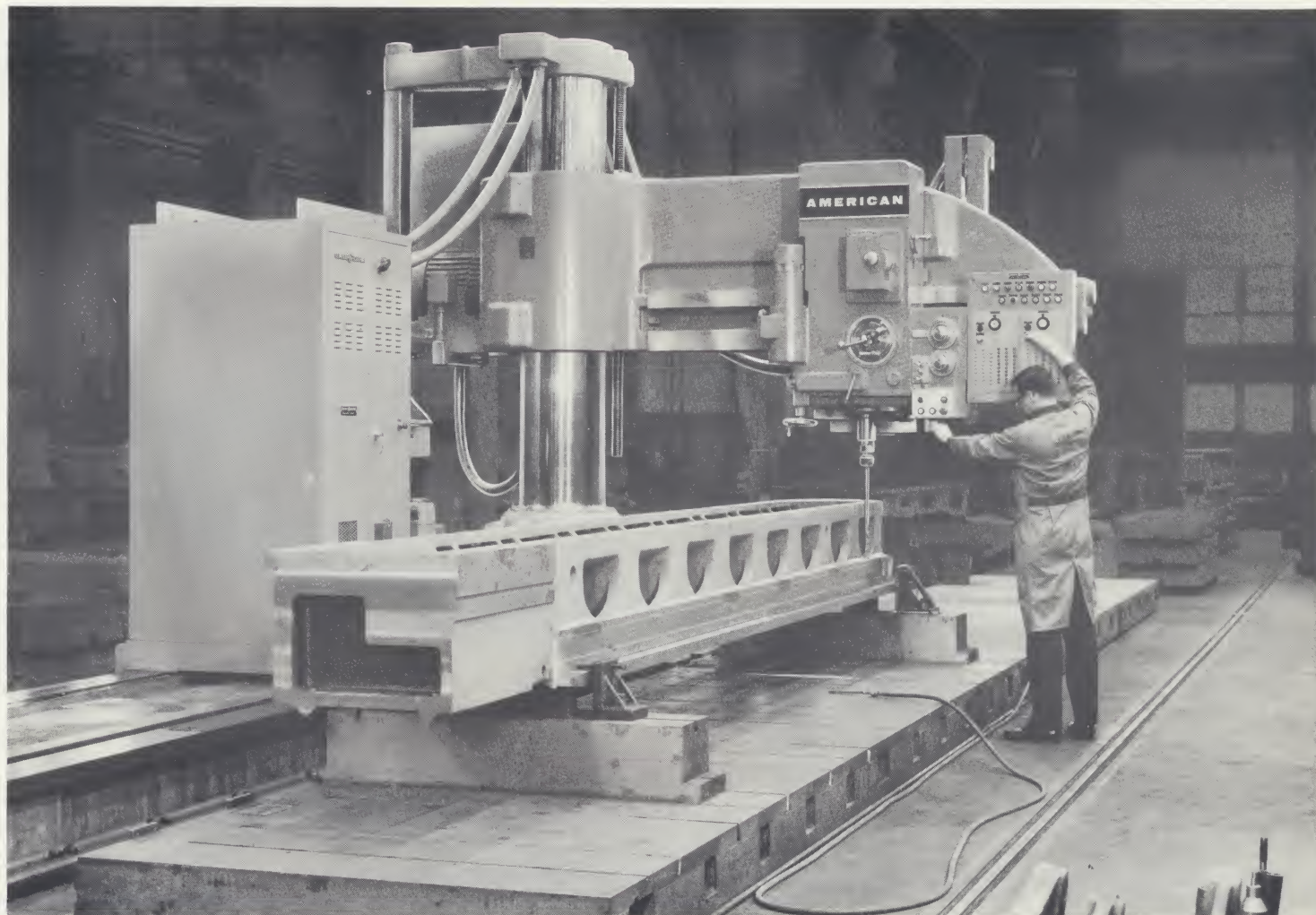
GENERAL ELECTRIC

Another example of modernized machining

American 819-32 Openside Boring and Drilling Machine

with
General Electric Mark Century* Numerical Control

*Trade Mark of General Electric Co.



... for automatic machining of extra large work.

FEATURES

- Three-mode control (tape, manual data input, manual pushbutton).
- Pre-selective hydraulic-power shift of speeds and feeds.
- Automatic spindle cycle.
- Full zero shift.
- Nitrided-nitralloy steel boring-mill-type spindle and sleeve.
- Solid one-piece column.
- 30-hp motor.

DESCRIPTION

The American 819-32 Openside Bor-

ing and Drilling Machine, equipped with General Electric Mark Century numerical control, performs machining on extra large work in an area 80 inches wide and up to 84 feet long. Ideal for boring and drilling massive engine bases, boiler plate and structural steel requiring precision hole spacing, it also performs small jobs positioned along its bed.

Three modes of control give complete versatility. When in tape control, the machine automatically machines any number of like holes without operator attention. Tool changes are accomplished during punched-in dwell periods, and

feeds and speeds are pre-selected by the operator. Manual data input, controlling X and Y movements, eliminates hand layout during short runs where tape is unwarranted. Manual pushbutton control is used when precise location of holes (such as eye-bolt holes) is not a factor.

TAPE CONTROL FUNCTIONS

- Positions tool in two axes.
- Signals automatic spindle cycle.
- Signals tool change.

SPECIFICATIONS

Main column diameter. 19"
 Auxiliary column size. 4" x 6"
 Type of spindle. precision boring mill
 Spindle nose taper & diameter. No. 6-4"
 Travel of spindle. 18"
 Maximum distance spindle to floor,
 with standard length column. 74 5/8"
 Minimum distance spindle to floor,
 with standard length column. 6 5/8"
 Minimum distance,
 center of spindle to
 column skirt and base. 15 1/4"
 Extreme over-all height. 147 3/8"
 Extreme over-all width with 80" Y travel. 206"
 Spindle speeds
 Number. 32
 Range. 20 to 1600 rpm

Feeds
 Number. 16
 Range. 0.003" to 0.125" per
 rev. of spindle
 Traverse of drill head on arm (Y axis) up to 80"
 Traverse of saddle on bed (X axis) From 4" min. to
 84" max.
 Positioning speed, each axis. 100" per min.
 Distance across saddle ways (runway) 56"
 Width of ways. 8"
 Traverse of arm on column. 50" min.
 Taper pipe tap leads,
 threads per inch. 8, 11 1/2, 14, and 18
 Main drive motor (maximum) 30 hp
 Numerical control
 Make. General Electric Mark Century
 Type. Punched tape and manual
 Zero shift. Full shift
 Approximate net weight of machine. 50,000 lbs.

THE PRODUCTS...

Lathe Bed

A total of 163 holes drilled and counterbored 13/16" in diameter and 17/32" deep, in a 50% steel cast-iron lathe bed.

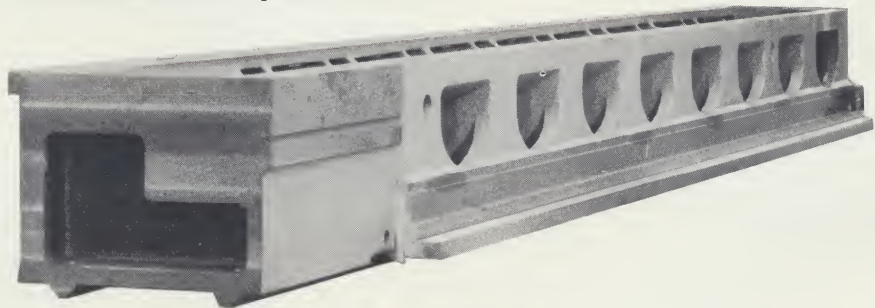
These holes were formerly machined with a 5' 11" travelling radial drill. Using jig step-clamped to the bed, nine holes on one side were drilled, then the last hole reamed and plugged, the jig removed and re-aligned and set for the next series of nine holes. This operation required that the jigs be set nine times, then the bed turned around. The same operations were repeated on the other side for a total of 18 jig settings.

The finished bed was removed before drilling could begin on another. The op-

eration required the full attention of the operator, plus the services of a crane operator. Minimum time for completing the job was 2.47 hours.

Performing the same operation with the American 819-32 Openside Drill re-

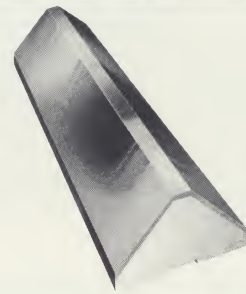
quires a maximum of 1.66 hours, or a reduction of 32%. Jigs and fixtures are eliminated. The operation is fully automatic, requiring only occasional operator attention.



Lathe Bed V-ways

Formerly, these hardened removable ways of Timken Graph - Mo steel required 1.65 hours each to drill eight 1 9/16" dia. holes, and required step changing the jig several times for the operation. The 5' 11" traveling radial drill formerly used could accommodate

only one V-way at a time. Using the American 819-32 Openside Drill, the same operation is accomplished in 35% less time. When required, V-ways can be set up to a maximum of 20 deep, limited in number only by the length of the bed. They can then be drilled automatically, without operator attention, saving a considerable amount of time.



AMERICAN

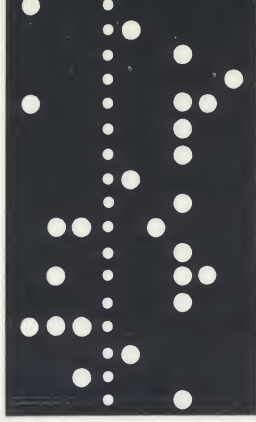
For more information on the American 819-32 Openside Boring and Drilling Machine, write to the American Tool Works Co., Pearl and Eggleston Ave., Cincinnati, Ohio.

THE AMERICAN TOOL WORKS COMPANY

Mark Century

For descriptive information on General Electric numerical control systems, write for bulletin GEA-7590, Distribution Services, General Electric Company, Schenectady, N. Y.

GENERAL ELECTRIC



Beatty #9 Structural Steel Angle Punch

with

General Electric Mark Century* Numerical Control

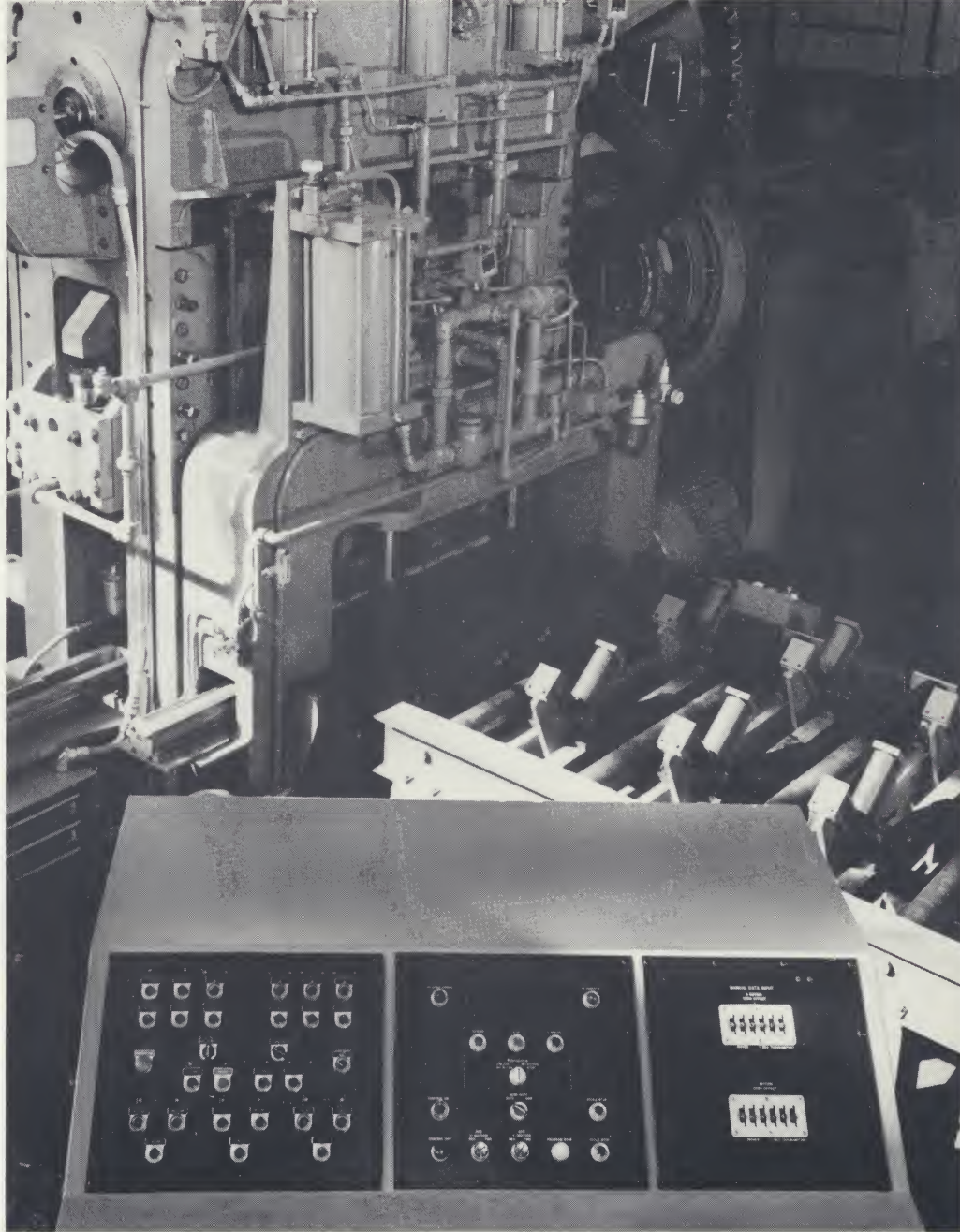
*Trade-mark of General Electric Company

**... automatically
punches
one leg of
two angles
in a single pass**

The Beatty #9 Structural Steel Angle Punch, equipped with General Electric Mark Century numerical control, automatically punches steel angles up to 50 feet long. Requiring only one operator, the machine moves the angles in a straight line on the spacing table, punching each leg in a single pass. To speed operation and reduce handling, the spacing table has a roll-over device that automatically releases and regrips the angles for punching the second leg. Fully automated, all machine functions are initiated by punched-tape commands.

FEATURES

- Numerically controlled punch tools and spacing carriage speed punching.
- Requires only one operator. Lowers labor cost. Reduces handling.
- Material moves in straight line on spacing table.
- Each leg punched in a single pass.
- Tools move automatically to satisfy gauge-line requirements.
- Equipped with angle positioners to control accuracy of gauge lines.
- Spacing table includes roll-over device to automatically release and regrip angles for punching second leg.
- Adapts to angles with equal or unequal legs.



SPECIFICATIONS

Capacity — up to 200 tons
Length of angles — up to 50 feet
Size of angles — $1\frac{1}{2}'' \times 1\frac{1}{2}'' \times \frac{1}{8}''$ to $8'' \times 8'' \times \frac{3}{4}''$
Spacing carriage speed — 250 ft/min.
Punch slide speed — 50 ft/min.
Hole location accuracy — $\pm 0.015''$
Capacity stencil unit, each angle—50 tons

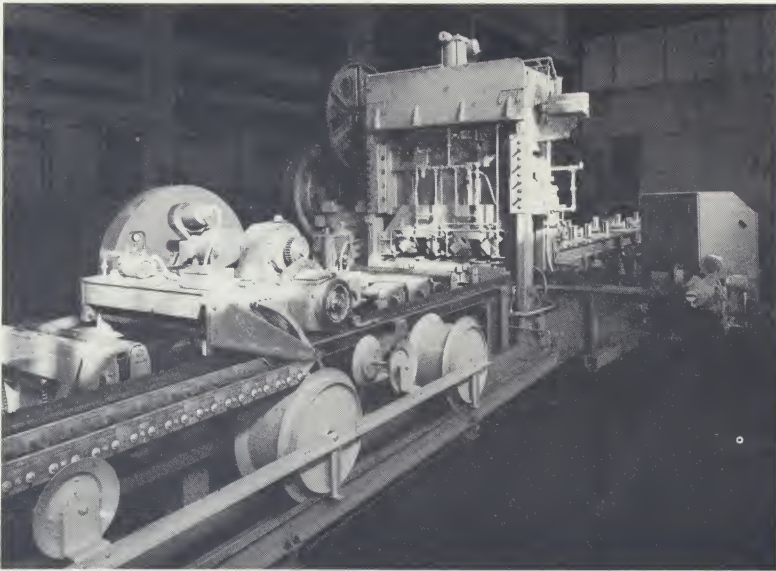
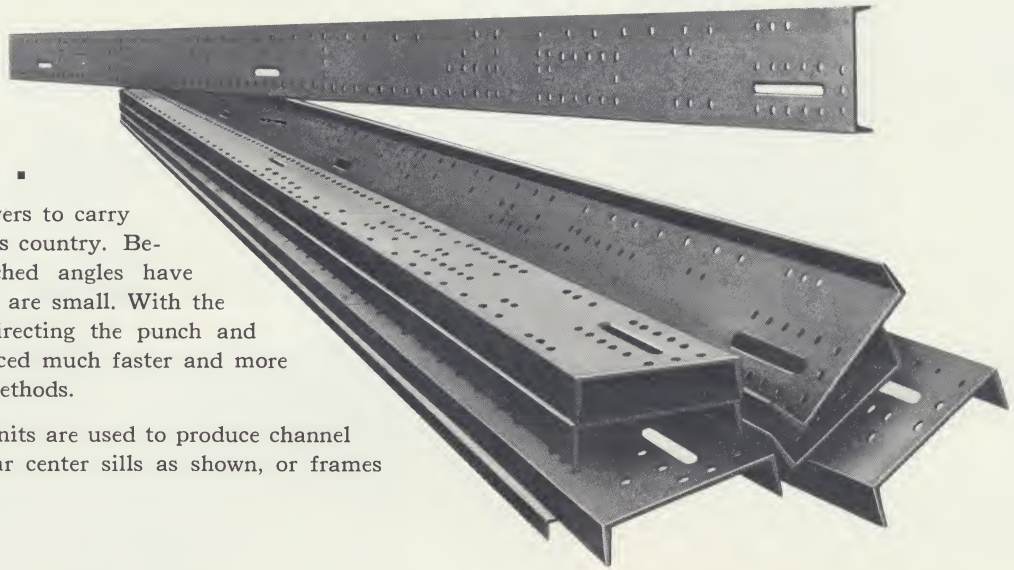
MACHINE/CONTROL FUNCTIONS

- Automatic movement of punch tools to meet gauge line requirements.
- Automatic movement of spacing carriage.
- Acceleration/deceleration control of material movements.
- Automatic control of roll-over device.

THE PRODUCT . . .

Punched angles are used in towers to carry power transmission cables across country. Because of land contours, punched angles have many variations and quantities are small. With the G-E Mark Century Control directing the punch and spacing table, angles are produced much faster and more accurately than conventional methods.

Similar punching and spacing units are used to produce channel sections used for rail freight car center sills as shown, or frames for trucks.



Beatty #9 Angle Punch spacing carriage and table shows positioners for punching both legs of angles. G-E numerical console, at right, gives operator clear view of the operation.

Roll-over device of Beatty #9 Angle Punch positions angles for punching of second leg when required. G-E control console and magnetic cabinet, at left, gives full view of punch.



For detailed information on the Beatty #9 Structural Steel Angle Punch with Numerical Control, write Beatty Machine & Manufacturing Company, Hammond, Indiana 46325.

BEATTY

BEATTY MACHINE AND MANUFACTURING COMPANY

Mark Century

For descriptive information on G-E Mark Century numerical contouring and positioning control systems, write for Bulletin GEA-7590, Distribution Services, General Electric Company, Schenectady, New York.

GENERAL  ELECTRIC

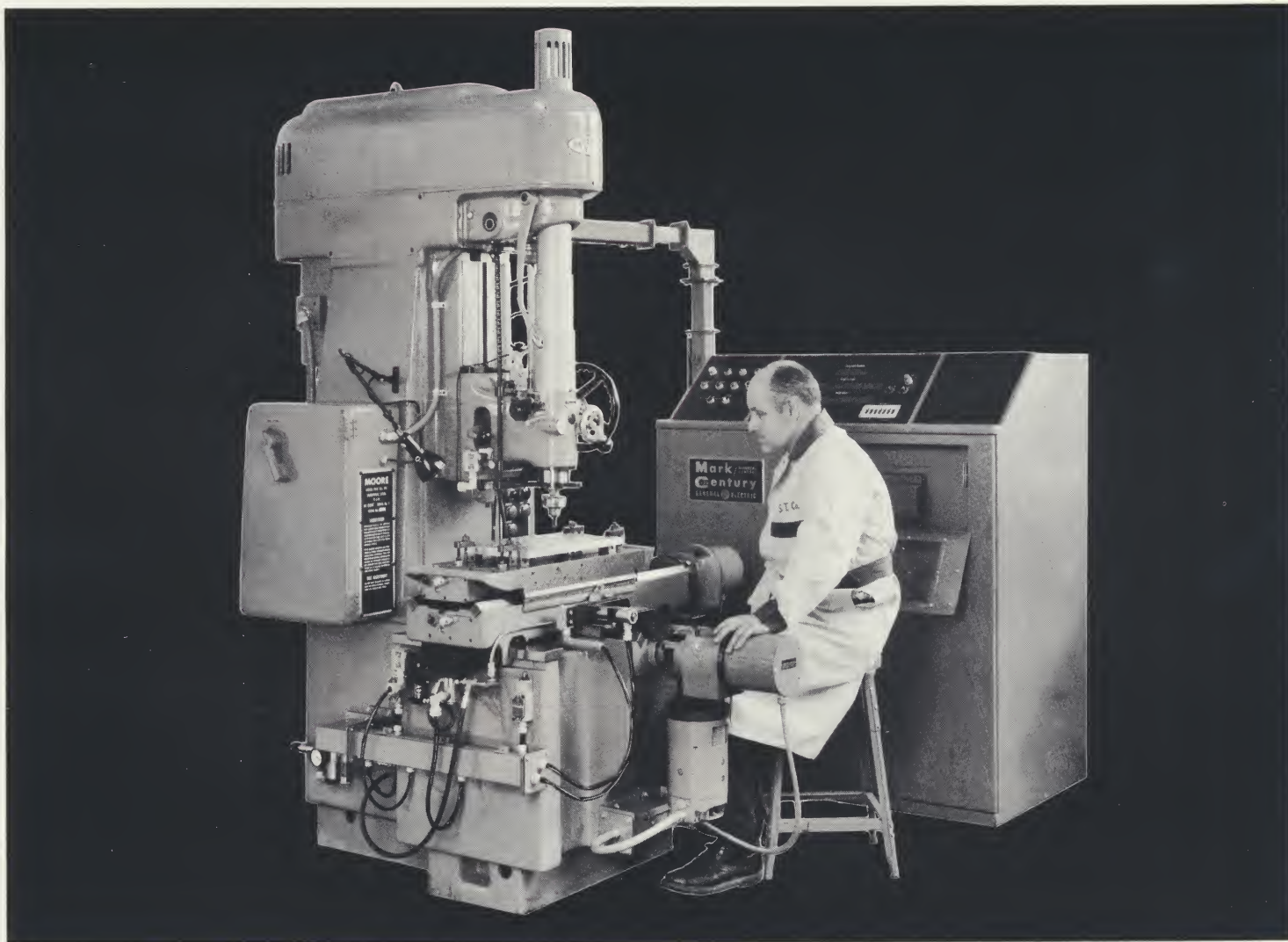
Another example of modernized machining

Model No. 3 Moore Precision Jig Borer

with

General Electric Mark Century* Numerical Control

*Trade-mark of General Electric Co.



. . . provides two-axis control for precise machining of tools, dies, gages, instrument components, space-age parts

FEATURES

- Hardened, ground, and lapped ways for permanence of accuracy.
- No overhang in machine travels.
- Hardened, ground, and lapped master lead screws for linear accuracy.

- Variable spindle speeds from 60 to 2250 rpm.
- Complete range of accessories and tools.

DESCRIPTION

The Model No. 3 Moore Jig Borer,

with General Electric Mark Century numerical control, machines with an accuracy of greater than 0.0001 inch. The precise tolerance is ideal for machining space age parts, precision tools, dies, gages, and instrument components.

NUMERICAL CONTROL FUNCTIONS

- Seven-digit input with 0.00001 inch program data resolution.
- Full range zero offsets for both axes.
- Absolute programming and positioning from adjustable zero reference.
- Manual data input in addition to tape.
- Automatic air clamp at position.
- Position can be read or set from dials and scales.
- Spindle cycle control.
- Block number readout.
- Block of 10 additional auxiliary functions.
- Feed rate selection by potentiometer or tape.
- Seven-digit readout.
- Plus and minus programming.

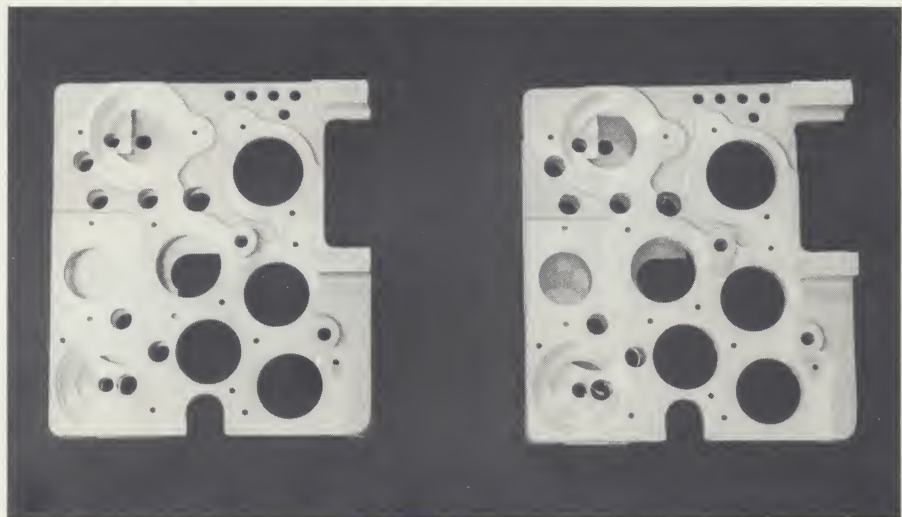
SPECIFICATIONS

Positioning accuracy	± 0.00015 inch
Table working surface	11 inches x 24 inches
Table travel	11 inches x 18 inches
Table top to spindle end	$3\frac{7}{8}$ inches x $20\frac{13}{16}$ inches
Spindle quill travel	5 inches
Spindle center to column ways	10 inches
Spindle center to column below ways	$13\frac{3}{4}$ inches
Spindle speeds	60 to 2250 rpm
Spindle feed	0.00075 inch: 0.0015 inch to 0.003 inch per spindle revolution

THE PRODUCT...

Typical of products that are machined with the Moore Jig Borer is this cast aluminum gear housing plate. Twenty different tools are used. The part has 19 gear centers which require a tolerance of $+0.0002$ inch on size, and $+0.0003$ inch on location for both X and Y axis.

Machining the part with the Mark Century numerically controlled Moore Jig Borer is several times faster than by manual operation. More important, the elimination of errors from less reliable manual operation amounts to considerable savings of time and materials.



For more information on the Model No. 3 Moore Jig Borer, write to Moore Special Tool Co., Inc., Bridgeport 7, Conn.

MOORE SPECIAL TOOL CO., INC.

**Mark
Century**

For descriptive information on General Electric numerical control systems, write for bulletin GEA-7590, Distribution Services, General Electric Company, Schenectady, N. Y.

GENERAL  ELECTRIC

Another example of modernized machining

SUNDSTRAND 3-AXIS, MODEL 21, JIGMATIC MACHINE

with General Electric Mark Century* Numerical Control

* Trademark of General Electric Co.

mills, drills, reams,
bores, taps, and changes
tools automatically

FEATURES

- Absolute positioning of 0.0005 in. per ft. (not to exceed ± 0.001 in.) when operating at uniform machine and ambient temperatures. Repeat accuracy: ± 0.0002 in.
- Table and spindle-head carrier supported by self-aligning, ball-bearing units on hardened, ground-steel ways.
- Feed and positioning have anti-backlash ball-screw drives.
- Rail is power elevated by matched, precision screws to help assure parallelism.
- Optical rail-position indicator has 0.0001 in. graduations to simplify accurate positioning.
- All primary machine functions (except rail positioning) are numerically controlled.
- Heavy-duty spindle is capable of 10 hp milling.
- Scales are graduated to 0.050 in. over the full length of X-, Y-, and Z-axes to facilitate set up.
- 10 coolant system is standard.
- All operating units (ways, drives, gear boxes, etc.) have automatic pressurized lubrication.
- Special panel light monitors the spindle mist-lubrication system.

DESCRIPTION

Sundstrand's Model 21 Jigmatic with G-E Mark Century numerical control is a 3-axis, rail-type machine featuring a 20-position automatic tool changer. This machine/numerical control combination automatically controls operations such as face-end milling, boring, counter-boring, drilling, tapping, reaming, and spot-facing. Coolant control, spindle speeds, feed rates, dwells, machine clamps, and tool selection and changing (optional) are also tape controlled.

The tool-changer drum holds 20 preset standard tool adapters in programmer-assigned positions. When a machin-

ing function is completed, a loader arm removes the tool from the spindle and replaces it with the next tool in the programmed sequence.

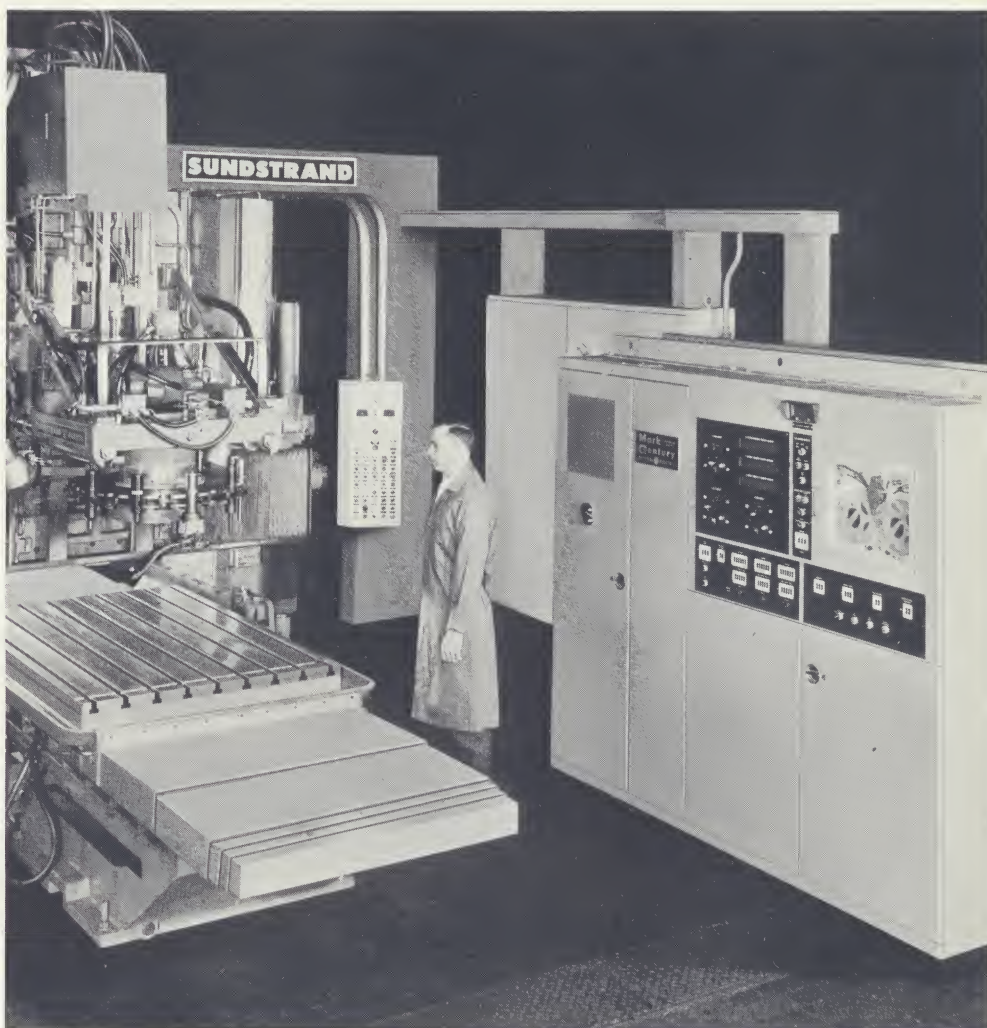
With automatic tool changing, simplified set ups, and numerical control of machining functions, machine time and costs are greatly reduced. Other savings include: lower-cost fixturing, elimination of jigs, longer tool life, less scrap, fewer machines and less floor space, faster scheduling, and fewer checking operations.

NUMERICAL CONTROL FUNCTIONS

- 3-axis simultaneous contouring

- Contouring speed steps up to 200 ipm without programming slowdowns or loss of synchronism
- GECENT postprocessor for APT users
- Photoelectric tape reader capable of reading 500 characters per second
- Manual data input
- 0.0001 to 99.999 in. programming
- Sequence number readout
- Block skip
- Rewind to "0" code (optional)
- Position readouts (optional)
- Circular interpolation (optional)

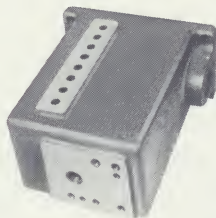
GENERAL  ELECTRIC



SPECIFICATIONS

Table size: Standard.....	66½ in. × 44 in.
Optional.....	90½ in. × 44 in.
Table stroke (X-axis): Standard.....	60 in.
Optional.....	84 in.
Max. weight of work piece	6000 lb.
Cross travel of vertical spindle (Y-axis).....	40 in.
Spindle head vertical stroke (Z-axis).....	24 in.
Rail adjustment (table to spindle face).....	2½ min. 44 max.
Spindle motor (d-c): Standard.....	7½ hp
Optional.....	10 hp
Spindle speeds (106 speeds each range):	
Low range.....	11 to 262 rpm
Medium range.....	29 to 720 rpm
High range.....	82 to 2000 rpm
Feed rates (all axes).....	½ to 200 ipm
Positioning rate.....	200 ipm

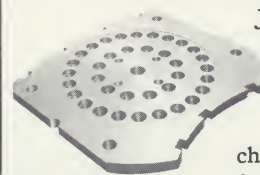
THE PRODUCTS



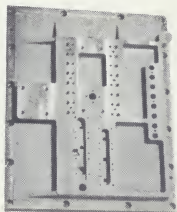
The Sundstrand Model 21 Jigmatic machine with G-E Mark Century numerical control makes this cast-iron switchbox in six operations but requires only three set ups. It takes just 36 minutes to drill 27 holes, tap 13, counterbore four, ream eight, and mill four surfaces and pads.



The Sundstrand Model 21 Jigmatic machine with numerical control can produce this part from a forging in about the same time it would take to machine a casting by conventional methods. Eliminating the pattern and casting for a design change saved the manufacturer \$10,000.



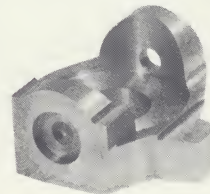
One Model 21 Jigmatic with numerical control replaces three conventional machines in manufacturing this piece. The operations: ruff and finish one 48¾ in. and one 22¼ in. radii, drill 54 holes, bore 116 holes, counterbore 36 holes, and chamfer 4 holes.



Machining time for this C.I. part is reduced from 17½ to 3½ hours. 19 tools automatically perform over 260 drilling, chamfering, counterboring, tapping, reaming, and slot-milling operations on top and bottom of the part.



No fixture needed for this part with Sundstrand Model 21 Jigmatic machine. Simple locator blocks and clamps position and hold this 39½ in. pallet plate part for drilling and tapping 75 holes, boring 6, and milling two 48 in. radii. Set up time: 45 minutes. Machining time: 61 minutes.



This steel pump wobbler part is drilled, bored, and contour-milled from the solid, in 2.5 hours. With previous method, production rate averaged 30 hours per part.

SUNDSTRAND

For more information on the Sundstrand Model 21 Jigmatic machine, write Sundstrand Machine Tool, Belvidere, Illinois.

SUNSTRAND MACHINE TOOL
BELVIDERE, ILLINOIS
DIVISION OF SUNDSTRAND CORPORATION

**Mark
Century**

For descriptive information on G.E. numerical control systems, write for bulletin GEA-7950, Distribution Services, General Electric Company, Schenectady, N. Y.

GENERAL ELECTRIC

Another example of modernized machining

SUNDSTRAND 5-AXIS OMNIMIL

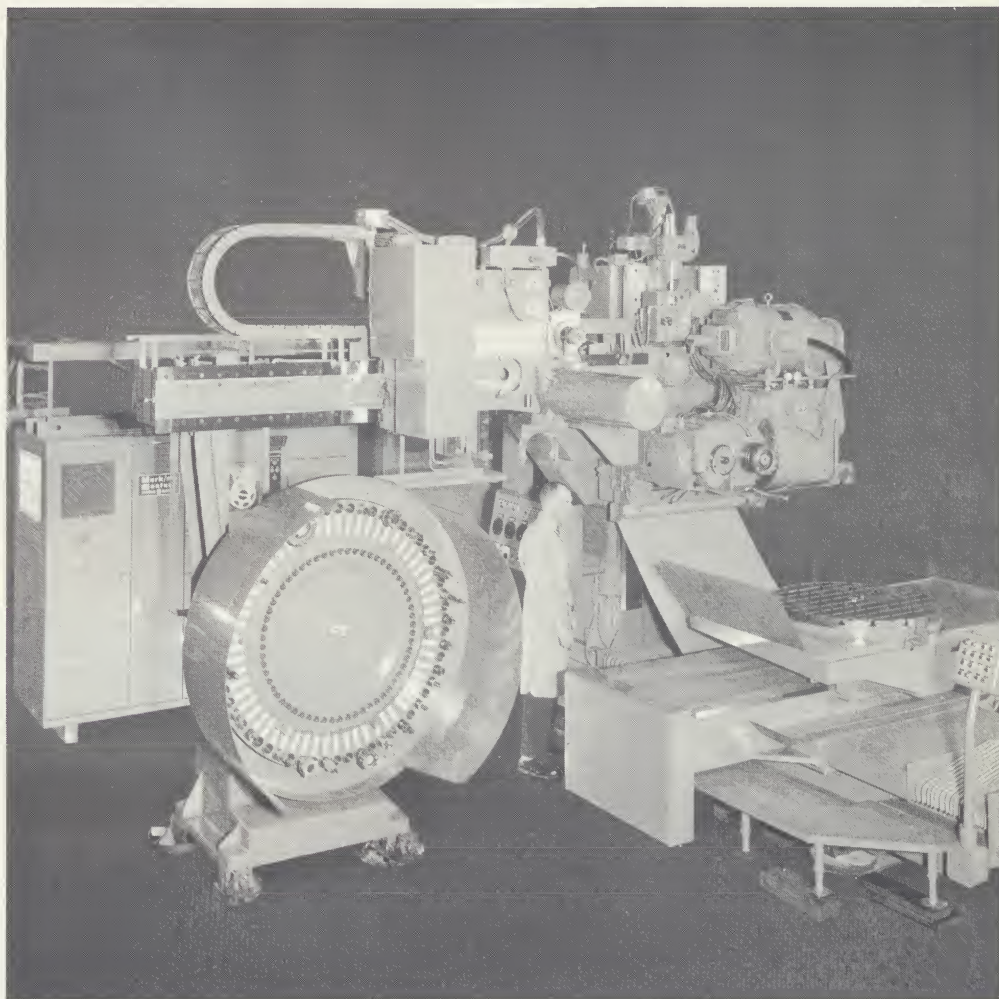
with General Electric Mark Century* Numerical Control

* Trademark of General Electric Co.

**an automatic,
single-machine
production line**

FEATURES

- High accuracy results from anti-friction construction, zero backlash, precision feedback, and precision measuring devices.
- Preloaded, recirculating, anti-friction ball packs guide and support the head.
- Less than eight pounds force can move table—even when loaded to 13,000 pounds.
- 2-degree internal head temperature change causes spindle growth of only 0.0001 in. for flange-located tools and only 0.00005 in. for shank tools.
- Measuring devices are close to machine work zone.
- Cast-iron machine members used throughout.
- Rotary table remains fixed in horizontal plane.
- Dual spindles: Low-speed spindle for rugged, full-horsepower cuts. High-speed spindle operates up to 4000 rpm.



DESCRIPTION

The Sundstrand 5-axis Omnimil with General Electric Mark Century numerical control will mill, drill, tap, ream, bore, counter bore, spotface, and contour mill any exposed surface of a work piece at any angle. Tool selection and changing (optional), coolant control, spindle speeds, feed rates, dwells, and machine clamps are all tape controlled.

This machine/numerical control combination can replace several different, limited-purpose machines. It simplifies fixturing, minimizes setups, reduces time per setup, and minimizes machine idle time.

Because the Omnimil performs so

many operations, many types and sizes of tools are normally used. To get optimum speed and performance from the machine, automatic tool changing is recommended. Automatic tool changing eliminates operator decisions, minimizes idle time, and increases chip-making time. The Sundstrand tool changer handles up to 60 coded tools ranging from small drills to large face-mill cutters.

NUMERICAL CONTROL FUNCTIONS

- 5-axis simultaneous contouring
- Contouring speed steps up 200 ipm without programmed slowdowns or loss of synchronism
- GECENT postprocessor has full 5-axis contouring capability for APT users
- Rewind to "O" code (optional)
- Photoelectric tape reader, 500 characters per second reading rate
- 0.0001 to 99.999 in.; 0.000001 to 0.99999 rev. programming
- Manual data input
- Dual photoelectric tape reader (optional with automatic pallet change)
- Position readout (optional)
- Circular interpolation (optional)
- Sequence number readout
- Block skip

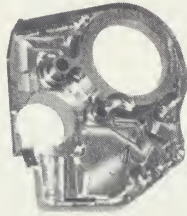
SPECIFICATIONS

Model OM-3		Model OM-4		25 hp head	40 hp head
Rotary table	42 in. dia.	Rotary table	52 in. dia.	52 in. dia.	52 in. dia.
Table longitudinal travel (X-axis) ..	48 in.	Table longitudinal travel (X-axis) ...	96 in.	96 in.	96 in.
Saddle transverse travel (Y-axis) ...	48 in.	Saddle transverse travel (Y-axis)	96 in.	96 in.	96 in.
Head vertical travel (Z-axis)	48 in.	Head vertical travel (Z-axis)	72 in.	72 in.	72 in.
Table rotary travel (C-axis)	360°	Table rotary travel (C-axis)	360°	360°	360°
Head rotary travel, total (A-axis) ...	150°	Head rotary travel, total (A-axis) ...	150°	360°	360°
Above horizontal	30°	Above horizontal	30°	—	—
Back of vertical	30°	Back of vertical	30°	—	—
Throat clearance	23 in.	Throat clearance	30 in.	30 in.	30 in.
Infinitely variable feed and position rates		Infinitely variable feed and position rates			
Table, saddle, and head—feed and positioning	0 to 200 ipm	Table, saddle and head—feed and positioning	0 to 200 ipm	0 to 200 ipm	0 to 200 ipm
Rotary motions—feed and positioning	0 to 2 rpm	Rotary motions—feed and positioning	0 to 2 rpm	0 to 2 rpm	0 to 2 rpm
Spindle speeds		Spindle speeds			
Low-speed spindle	12 to 1000 rpm	Low-speed spindle	12 to 1000 rpm	10 to 540 rpm	10 to 540 rpm
High-speed spindle	50 to 4000 rpm	High-speed spindle	50 to 4000 rpm	69 to 3719 rpm	69 to 3719 rpm
High-speed spindle stroke	7½ in.	High-speed spindle stroke	7½ in.	—	—
Spindle motor	25 hp	Spindle motor	25 hp	40 hp	40 hp

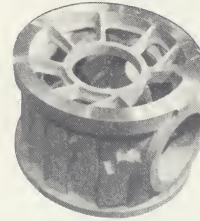


16.7 hours machining time saved on this part. The Sundstrand 5-axis Omnimil with G-E Mark Century numerical control drills 51 holes (three sizes), drills and taps 65 holes (two sizes), and mills and bores 20 notches—all in 1.8 hours.

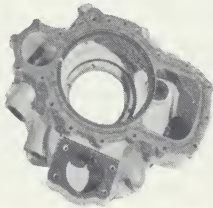
THE PRODUCTS



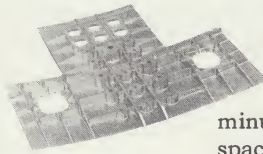
Complex contour and pocket milling to precision tolerances reduced a solid block of stainless steel and titanium to this thin-walled housing in just 14 hours. The same operation previously took 120 hours with conventional equipment.



A Sundstrand 5-axis Omnimil with numerical control does a day's work in 30 minutes. This magnesium transmission housing is milled, drilled and bored in 30 minutes. Setup time is four hours. Previously, the same part required seven hours to machine, 21 hours to setup, and it took six machines to do the job.



One Sundstrand 5-axis Omnimil with numerical control replaced 29 machines and saved 10 hours machine time in the manufacture of this part. The aluminum housing is milled, drilled, tapped, and counter-bored in three setups. The old method required 29 setups on 29 separate machines.



324 hours are saved on this aluminum part for a space vehicle. Complete contour machining is performed in 54 hours, compared to an estimated 378 hours by conventional means.



The Sundstrand 5-axis Omnimil makes its own fixture for operation on tool transport housing. Using a modular fixture as a base, blocks and buttons are assembled and then machined for central, radial, and height location. Total time for fixture making is 40 minutes. 138 machining operations, including drilling, tapping, boring, counterboring, reaming, and milling take only 95 minutes.



For more information on the Sundstrand 5-axis Omnimil, write Sundstrand Machine Tool, Belvidere, Illinois.

SUNDSTRAND MACHINE TOOL
BELVIDERE, ILLINOIS
DIVISION OF SUNDSTRAND CORPORATION

Mark Century

For descriptive information on General Electric numerical control systems, write for bulletin GEA-7950, Distribution Services, General Electric Co., Schenectady, N. Y.

GENERAL ELECTRIC

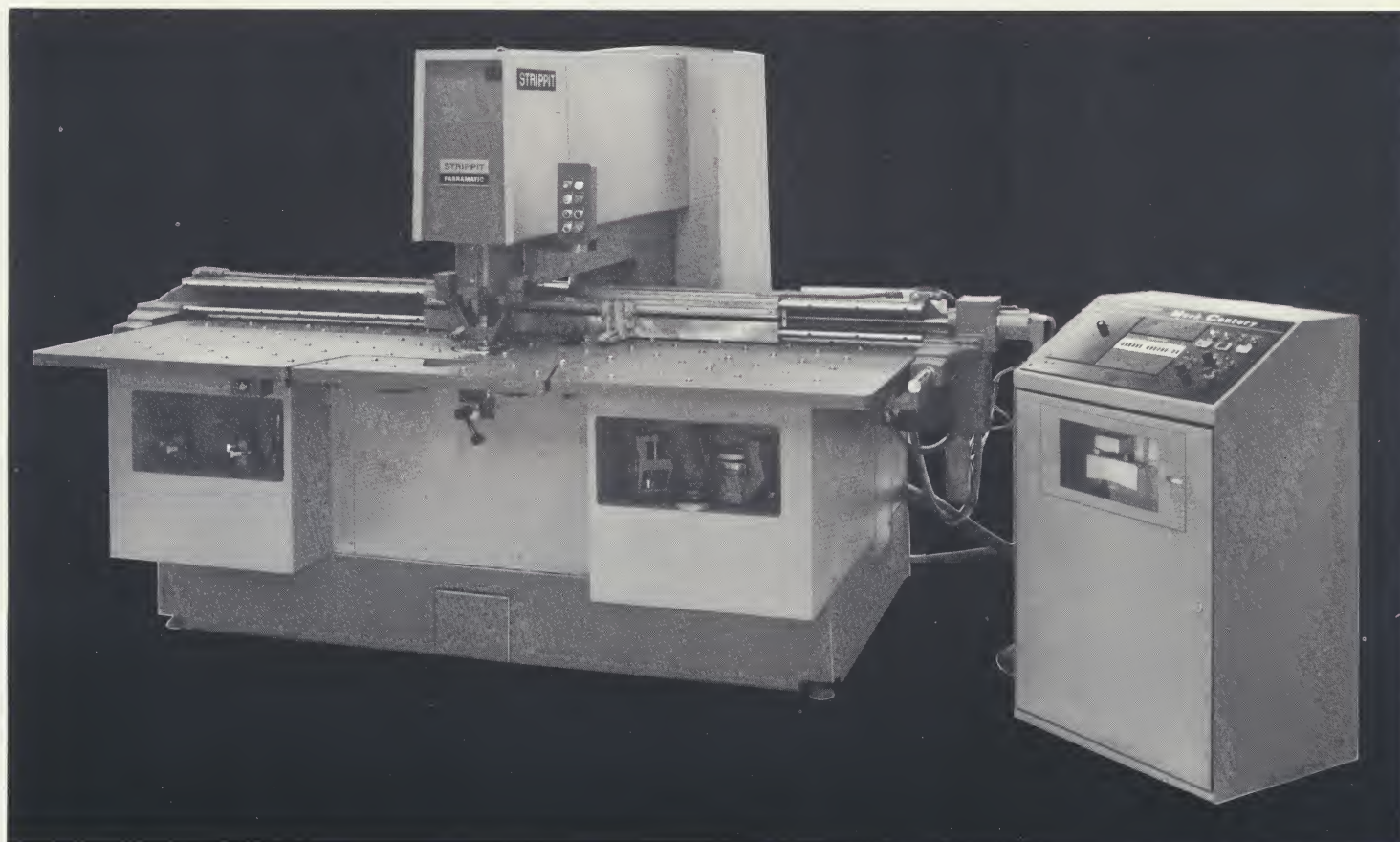
Another example of modernized machining

Strippit Fabramatic[†] 30

with

General Electric Mark Century^{*} Numerical Control

*Trade-mark of General Electric Co.
†Trade-mark of Wales Strippit Co.



. . . provides low cost, flexible automation for punching and notching up to 1/4" thickness

FEATURES

- Three mode control (auto, semi-auto, manual)
- Large capacity, high tonnage
- Low initial cost
- Fast, unlimited tool changes
- Simple operation
- ± 0.003 " accuracy

DESCRIPTION

The Strippit Fabramatic 30, with General Electric Mark Century 120 numerical control, is designed for the shop with short run production of complex workpieces.

Fabramatic 30 is the low cost answer

to increased flexibility and profitability. It combines modularized solid-state electronic controls with fast, unlimited tool changes.

Savings with the machine are realized in set-up time, operating time, tooling costs, productivity, reduced scrap, less inspection and more efficient machine and operator utilization.

The Fabramatic 30's deep throat handles nominal sheet material 30" x 48"—or up to 60" by any length—with material capacity of 1/4" thickness. Round and shaped holes up to 3 1/2" diameter—noses and cutouts of practically unlimited variety—are all punched automatically at one machine . . . with one operator. Repositioning sheet with the

automatic progressive move option increases capacity to meet practically any requirement.

In addition to its maximum size capacity (60" x any length) and press capacity (30 tons), the Fabramatic 30 offers other unique features that multiply its versatility. Three modes of operation—auto, semi-auto, and manual—allow for automatic, semi-automatic, or manual control of the machines positioning and punching functions.

All the inherent advantages of numerical control, the benefits of Strippit's unique cost-reducing tooling, and the assurance of continual ± 0.003 " accuracy are for the first time, available in the Fabramatic 30.

NUMERICAL CONTROL FUNCTIONS

- Resolution of 0.0001" allows you to program 4-digit decimal equivalents of common fractions.
- Absolute dimensioning system rules out accumulative error.
- Variable block work address format reduces programming time and length of input tapes.
- Photoelectric tape reader handles 100 characters per second.
- Transistorized solid state logic circuitry used throughout.
- Full proportional SCR servo system with matched 1/8 HP motors assures accurate positioning at maximum punching rate.

SPECIFICATIONS

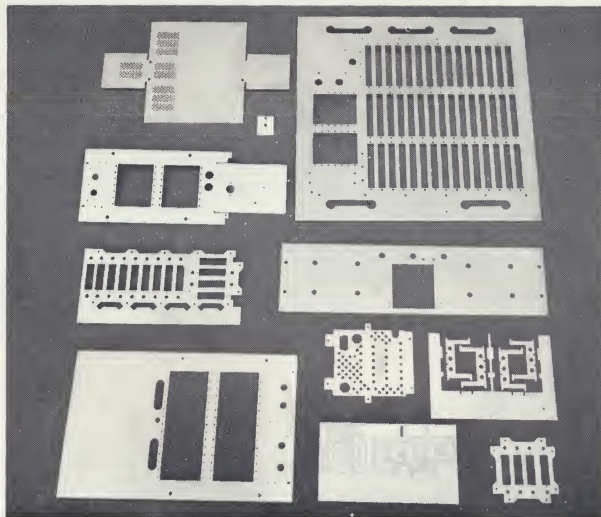
Maximum Material Capacity 1/4"
 Press Capacity 30 tons
 Holes Per Minute 50 on 1" centers
 Workpiece Size 30" x 48" nominal
 (60" x any length with Automatic Progressive Move System)
 Punch Motor ... 1 1/2 hp, 1200 rpm, 220 or 440 volts, 3 phase,
 60 cycle (voltage, phase and cycle altered
 to customer's requirements at extra cost)
 Carriage Travel 250 ipm

Shut Height 5 13/32" with punches and dies
 mounted in holders
 Shipping Weight approximately 10,000 lbs
 Width 122 7/8"
 Height 73"
 Depth 114"
 Table Height 37 11/16"

THE PRODUCT...

Typical of the products that are produced with the Strippit Fabramatic 30 are these machined aluminum and steel pieces. As many as 15 different tool changes were involved in some of the more intricate pieces.

Machining these parts with the Mark Century numerically controlled Strippit Fabramatic 30 is several times faster than by manual operation. More important, the elimination of errors associated with less reliable manual operation amounts to considerable savings of time and materials.



WALES STRIPPIT
 COMPANY
 AKRON, NEW YORK 14001

For more information on the Strippit Fabramatic 30 write to Wales Strippit Company, Akron, New York 14001. A unit of Houdaille Industries, Inc.



Mark
Century

For descriptive information on General Electric numerical control systems, write for bulletin GEA-7590, Distribution Services, General Electric Company, Schenectady, N. Y.

GENERAL ELECTRIC

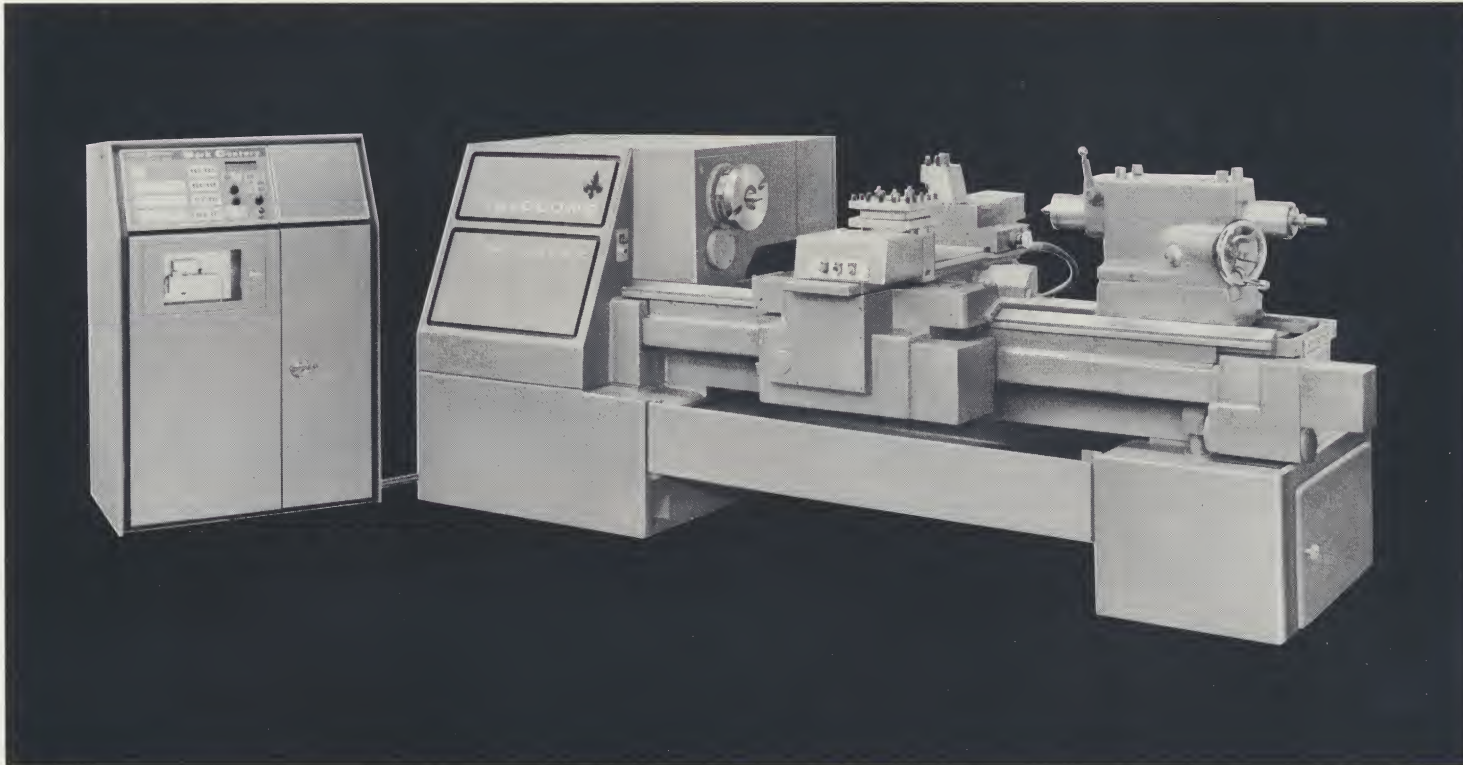
Another example of modernized machining

LEBLOND TAPE-TURN IIS Lathe

with

General Electric Mark Century* 100S Numerical Control

*Trade-mark of General Electric Company



Heavy duty shaft lathe for between center operations

FEATURES

- G-E Mark Century 100S Numerical Control provides complete command of all machining operations
- Full contouring capability for straight cuts, slopes or arcs
- 12-position, square tool turret at front, with optional single point inverted tool at rear
- 12-speed full-power headstock with 30 hp drive, speed ranges from 23 to 1520 rpm
- Heavy duty tailstock handles large loads

DESCRIPTION

LEBLOND TAPE-TURN IIS lathes with General Electric Mark Century Numerical Control provide full contouring capabilities with cost savings in operating time, efficiency, while eliminating errors in judgement. Production management is in direct control of the tool. Predictable results are obtained repeatedly. New designs can be programmed and tested at lower costs than conventional methods.

Tooling arrangement for the Tape

Turn IIS includes a 12-position square turret at the front and the option of a single point inverted tool at the rear. High speed, carbide, or ceramic tooling may be used.

Tape-Turn IIS lathes will chase all types of standard threads, and will thread leads from fine pitch to over 1" on lengths, cross axis, or tapered sections.

Standard production operations are possible in all speed ranges. The headstock is available in any one of three speed-range combinations (see specifications). The standard range of 23 to 1520 rpm delivers full horsepower at all speeds from the 30 hp drive motor. Tape Turn IIS carriages have exceptionally large non-metallic bearing surfaces, controlled pressure lubrication, a rectangular, compensating replaceable guideway, and a drive directly under the guideway. This assures smooth feeding with no twist, climb, or cramp. A preloaded recirculating ball bearing nut on a precision screw drives the carriage.

The cross slide is also driven by a preloaded, recirculating ball nut on a hardened and ground screw. Automatic

compensation for position on both axes is inherent. Incremental feed systems range from .1" to 20" per minute with rapid traverse rate of 100" per minute.

Compensating bed way design combines a wide rear carriage bearing surface with a front 20°-70° guideway to maintain accurate alignment. Replaceable bed ways are made of hardened and ground graphitic self-lubricating tool steel.

NUMERICAL CONTROL FUNCTIONS

- Specifies absolute electrical positioning accuracy of $\pm .0005"$.
- Controls four pairs of tool offsets with $\pm .0099"$ range; any pair may be tape selected for any tool.
- Controls cutting movements toward head- or tail-stock, cuts parallel to X or Z axis or at any angle to them, or in clockwise or counterclockwise arcs.
- Repeat electrical positioning accuracy of $0.0002"$, with system resolution of $0.0001"$.
- Provides out-of-sync protection, tape parity check, 20 auxiliary mode functions, simplified tape testing.

SPECIFICATIONS

General

	Tape-Turn IIS
Swing over bed and carriage wings	25"
Swing over cross slide without rear rest	13"
Distance between centers, base length	78"
Center distance increases in increments of	24"
Distance, spindle center to floor	44 $\frac{3}{4}$ "

Headstock

Gear ranges	2
Clutch ranges, by tape	6
Spindle speeds, by tape for each gear range	60
Spindle speeds, tape commanded in each gear range (standard) rpm	
Range 1	Range 2
23 to 68	34 to 101
51 to 154	76 to 228
113 to 338	172 to 515
67 to 200	99 to 298
151 to 453	224 to 672
332 to 995	507 to 1520
Speed points in each clutch range	10
Speed points in each gear range	60
Spindle, diameter at bearings	4 $\frac{1}{2}$ ", 4", 3 $\frac{3}{8}$ "
Front spindle bearing, Timken precision, O.D.	7 $\frac{1}{2}$ "
Front spindle bearing, radial load at 100 rpm	21,000 lbs.
Center spindle bearing, Timken precision, O.D.	6 $\frac{5}{8}$ "
Rear spindle bearing, O.D.	5.118"
Spindle, size of center, Morse No.	4
Spindle nose	L-1
Headstock, length on bed	30 $\frac{3}{4}$ "

Tailstock

	Tape-Turn IIS
Spindle diameter	4 $\frac{1}{2}$ "
Size of center, Morse No.	4
Spindle travel	12 $\frac{1}{2}$ "
Length on ways	17 $\frac{1}{2}$ "
Set-over, either side of center	1 $\frac{1}{4}$ "

Carriage & Slides

Length on ways	32"
Turret slide travel	18"
Power turret, tape commanded, positions	12
Curvic coupling, diameter	9"
Size of tool	1" x 1 $\frac{1}{4}$ "
Rate of rapid traverse, slide and carriage, ipm	100
Precision ball feed screw, cross, dia.	1 $\frac{3}{8}$ "
Precision ball feed screw, length, dia.	1 $\frac{3}{4}$ "

Feeds

Length of cross, in. per min.	0.1 to 20
Increment of feeds, in. per min.	1
Feed drive motor, 1750 rpm, length, hp	$\frac{3}{4}$
Feed drive motor, 1750 rpm, cross, hp	$\frac{3}{4}$

Bed

Width	20"
-------	-----

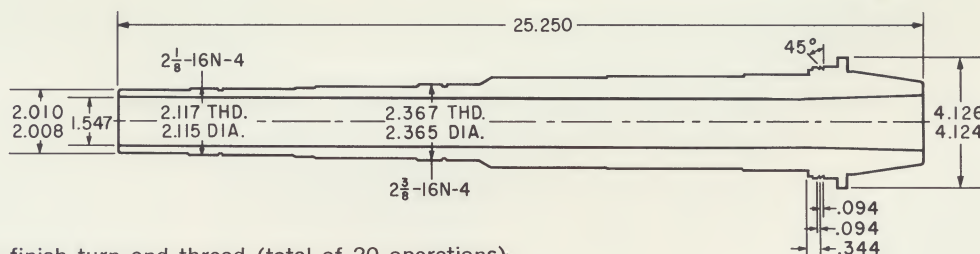
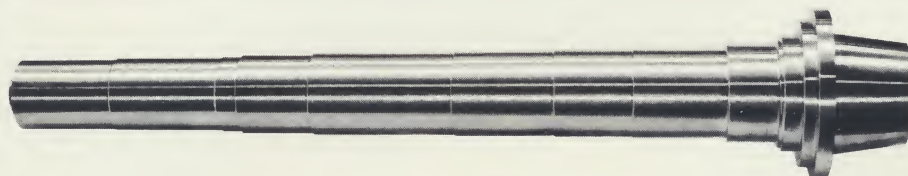
Motor Data

Maximum motor hp and rpm (standard)	30,567/1800
Number of speed points in 3:1 range, by tape	10

Shipping Data

Domestic shipping weight, base length with average accessories, and electrics	16,400 lbs.
Floor space, base length	164" x 52"
Floor space, electric console	38" x 28"

THE PRODUCT



Operations: Rough turn, finish turn and thread (total of 20 operations)
Material: 4140 forging

	Previous Time (Tracer Lathe)		Present Time (Tape-Turn IIS Lathe)	
	Rough	Finish	Rough	Finish
Setup Time	180 min.	222 min.	60 min.	60 min.
Machining Time per Piece	12.5 min.	35.0 min.	8.3 min.	10.4 min.



For more information on TAPE-TURN IIS lathes, write to the R. K. LeBlond Machine Tool Company, Madison at Edwards Road, Cincinnati, Ohio 45208.

THE R. K. LeBLOND MACHINE TOOL COMPANY

Mark 100 Century

For descriptive information on General Electric Numerical Control systems, write for N/C Data File, GEZ-3774A, Distribution Services, General Electric Company, Schenectady, New York 12305.

GENERAL  ELECTRIC

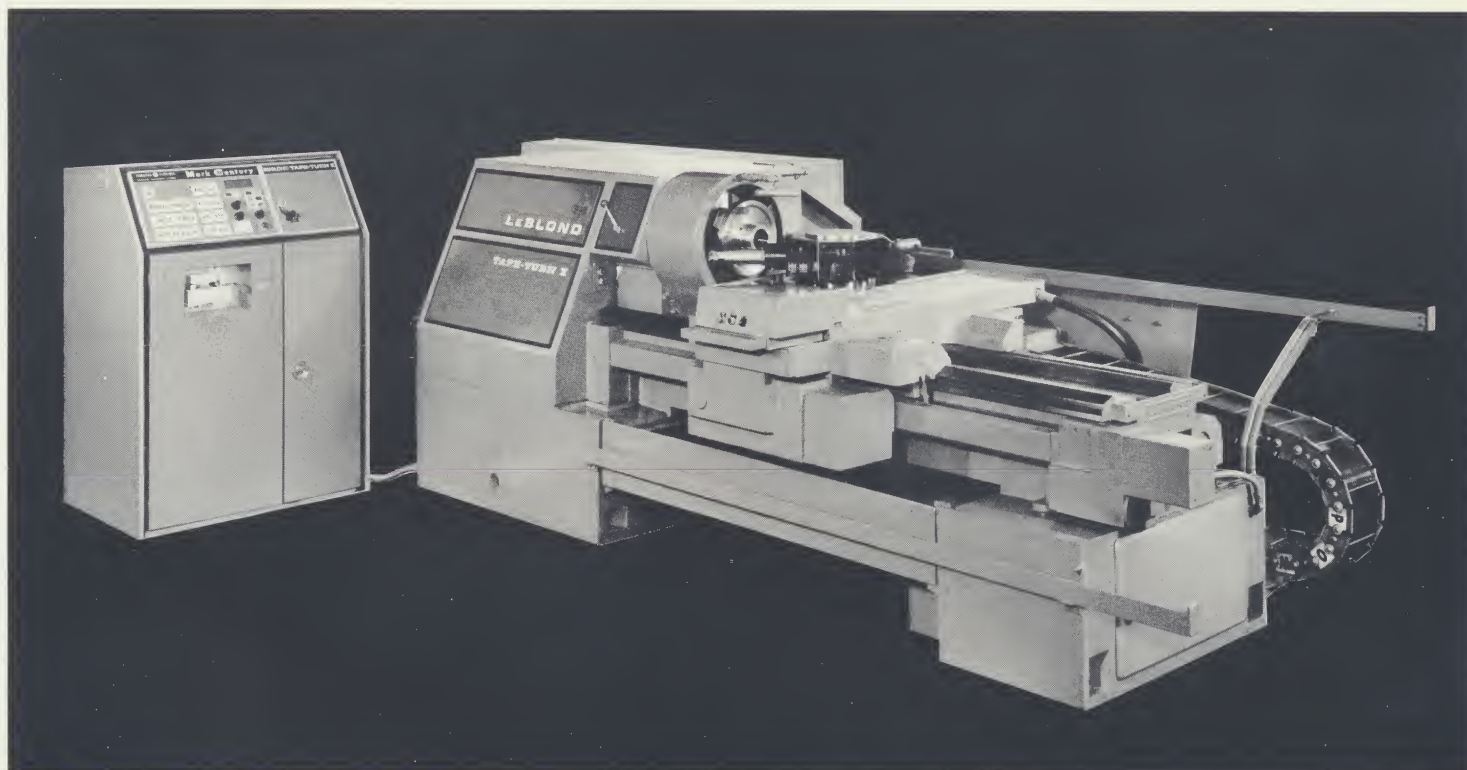
Another example of modernized machining

LEBLOND TAPE-TURN IIC Lathe

with

General Electric Mark Century* 100S Numerical Control

*Trade-mark of General Electric Company



Heavy-duty lathe designed for chucking operations

FEATURES

- G-E Mark Century 100S Numerical Control provides accurate positioning to $\pm .0005''$.
- Full contouring capability for straight cuts, slopes, or arcs.
- Precision carriage with rectangular replaceable guideways assure smooth feeding.
- Full power headstock with 30 hp drive provides 8 to 1 variable speed, 120 speeds.
- "L" shaped bed at head end provides solid headstock support.

DESCRIPTION

The LeBlond Tape-Turn IIC lathe is equipped with a six-station, twelve position tool turret, and General Electric Mark Century Numerical Control for full contouring capability with predict-

able performance on each job.

Optical tool setting allows the use of throw away tool inserts and holders. Tool cutting edge can be set to $\pm .0015''$.

Full power headstock on the Tape-Turn IIC has a 30 hp drive motor and 8 to 1 variable speed. Tape controlled speed shifts—there are 120 speeds from 27 to 1210 rpm—are accomplished by electric clutches.

Smooth feeding of the carriage is due to extra large bearing surfaces of non-metallic material, controlled pressure lubrication, a rectangular, compensating guideway, and a drive directly under the guideway. A preloaded recirculating ball bearing nut on a precision screw further assures smooth feeding.

The cross slide is also driven by a preloaded recirculating ball nut on a hardened and ground screw. In addition, this

system includes automatic compensation for position on both axes and assures tool position with closer tolerances than otherwise possible.

NUMERICAL CONTROL FUNCTIONS

- Controls cutting toward headstock or tailstock, parallel to X or Z axes or at any angle to them, or in clockwise or counterclockwise arcs.
- Repeat electrical positioning accuracy of $.0002''$, with system resolution of $.0001''$.
- Controls four pairs of tool offsets with range of $\pm .0099''$, any pair may be tape-selected for any tool. Controls feed, tool turret positioning, and 120 speeds.
- Provides out-of-sync protection, tape parity check, 20 auxiliary mode functions, simplified tape testing.

SPECIFICATIONS

General

Swing over bed and carriage wings	25"
Swing over cross slide without rear rest (7.5" for shaft work)	13"
Stroke, length axis-base length of bed	9'6"
Minimum distance—face of spindle to face of turret	4 1/8"
Distance, spindle center to floor	44 3/4"

Headstock

Gear ranges	2
Clutch ranges, by tape	6
Spindle speeds, by tape for each gear range	60
Spindle speeds, tape commanded in each gear range (standard) rpm	

Range 1

27 to 82, 40 to 121,
60 to 180, 75 to 275,
136 to 408, 207 to 622

Range 2

53 to 159, 78 to 236,
120 to 361, 178 to 535,
265 to 794, 403 to 1210

Speed points in each clutch range	10
Speed points in each gear range	60
Spindle, diameter at bearings	5 7/8", 5 1/2"
Front spindle bearing, Timken precision, O.D.	9 5/16"
Front spindle bearing, radial load at 100 rpm	37,000 lbs.
Rear spindle bearing, O.D.	9 5/16"
Spindle nose	11" A-1
Headstock, length on bed	30 3/4"

Carriage & Slides

Length on ways	40"
Turret slide travel	19"
Power turret, tape commanded, positions	12
Turret size	9" square or 12" hexagonal
Size of tool	1" x 1 1/4"
Rate of traverse, slide and carriage, ipm	100
Precision ball feed screw, cross, dia.	1 3/8"
Precision ball feed screw, length, dia.	1 3/4"

Feeds

Length of cross, in. per min.	0.1 to 20
Increment of feeds, in. per min.	0.1
Feed drive motor, 1750 rpm, length, hp	3/4
Feed drive motor, 1750 rpm, cross, hp	3/4

Bed

Width	20"
-------	-----

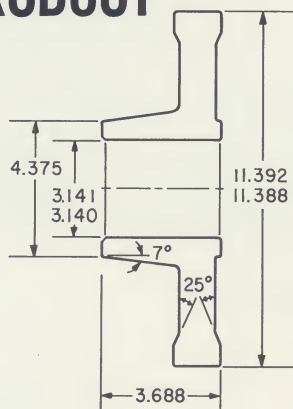
Motor Data

Maximum motor hp and rpm (standard)	30, 567/1700
Number of speed points in 8:1 range, by tape	10

Shipping Data

Domestic shipping weight, base length with average accessories, and electrics	16,400 lbs.
Floor space, base length	164" x 52"
Floor space, electric console	38" x 28"

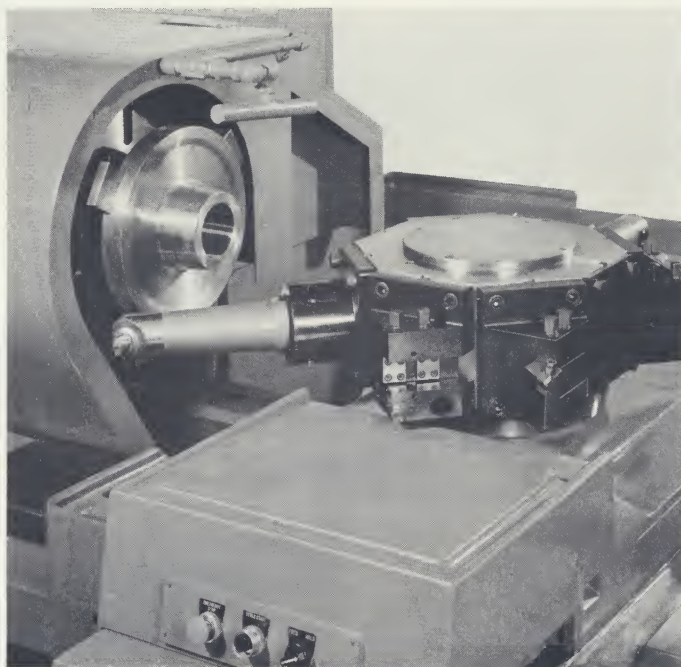
THE PRODUCT



Operations: Turn, face and bore complete from forging
Material: 4140 forging

	Previous Time (Production Chucking Lathe)	Present Time (Tape-Turn IIC Lathe)
--	--	---------------------------------------

Setup Time—2 operations	555 min.	90 min.
Time per Piece—2 operations	22.2 min.	16.0 min.
Savings	83.8% Setup 28% Machining	



For more information on TAPE-TURN IIC lathes, write to the R. K. LeBlond Machine Tool Company, Madison at Edwards Road, Cincinnati, Ohio 45208.

THE R. K. LeBLOND MACHINE TOOL COMPANY

Mark 100 Century

For descriptive information on General Electric numerical control systems, write for N/C Data File, GEZ-3774A, Distribution Services, General Electric Company, Schenectady, New York 12305.

GENERAL  ELECTRIC

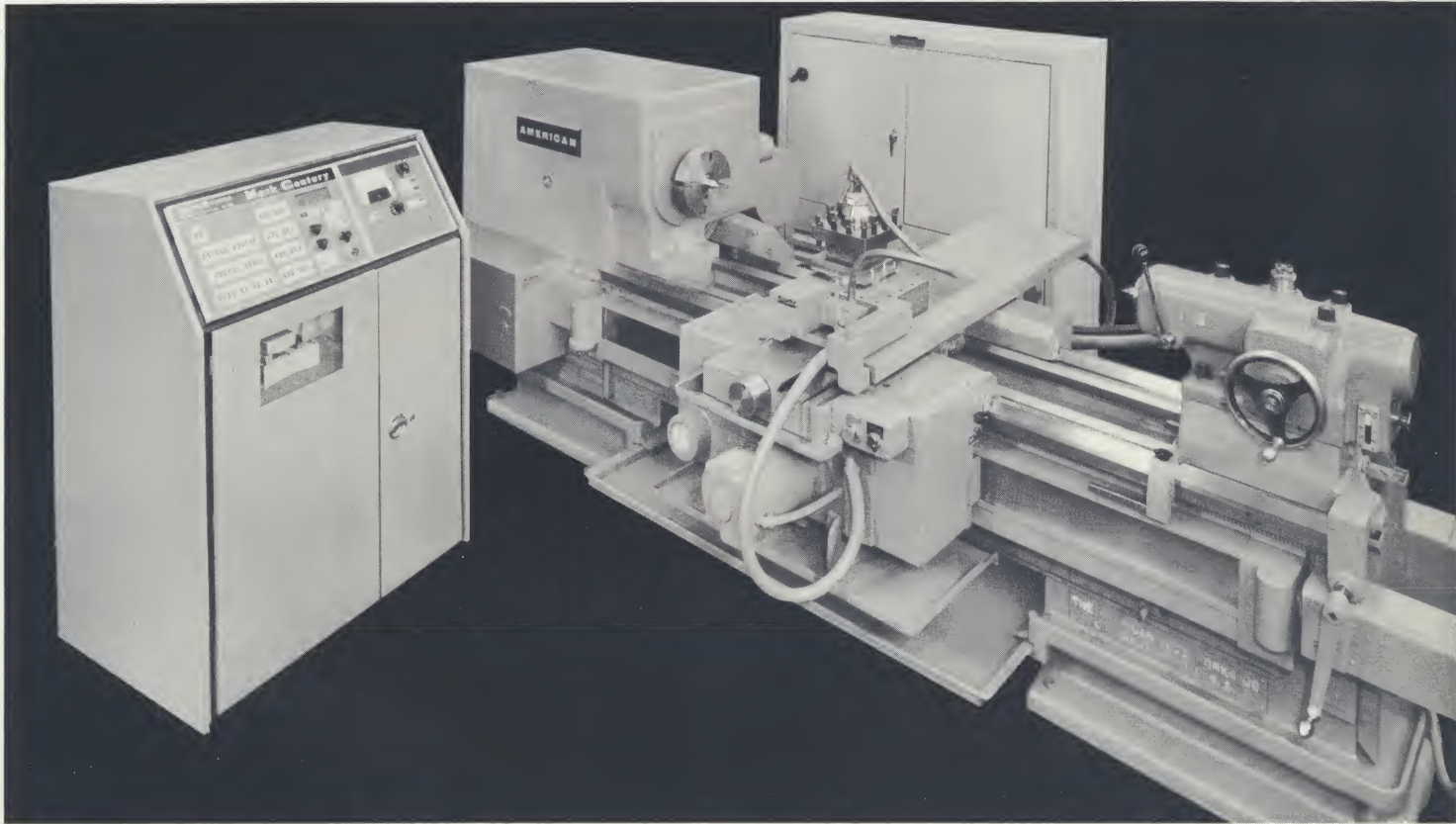
Another example of modernized machining

AMERICAN TAPE-CONTROLLED LATHE

with

General Electric Mark Century* 100S Numerical Control

*Trademark of General Electric Co.



Heavy-duty capacity with "STRESS-FREE" fixturing capability

FEATURES

- Specially designed turret resists deflection during boring operations
- Holds fragile parts relatively "STRESS-FREE"
- Massive, heavy-duty construction with precision tolerance capability on all jobs
- Tool selection and tool offsets can be selected by one T-word
- G-E Mark Century 100S Numerical Control gives predictable accuracy for all lathe functions
- Anti-friction tailstock spindle center
- Three bearings support headstock spindle
- Full-floating zero, plus differential resolver
- Electric tool turret clamp

- 20 speed selections in each of two ranges

DESCRIPTION

The American Tape-controlled Lathe with General Electric Mark Century 100S Numerical Control provides completely automatic machining operations. Interchangeable turret tool holder, either square or hexagonal, is held in place on a curvic coupling by a single nut for quick changes.

Automatic, semi-automatic, or manual machine mode selector gives the operator full control of all machining operations. Four pairs of tool zero offsets aid the operator in precisely setting the tool cutting edge. Any pair of offsets may be used for any of nine possible

tools. Zero position pushbutton enables the operator to set all control motions at their zero limit switches. Once this is done, the lathe is fully synchronized and ready to begin a new program.

NUMERICAL CONTROL FUNCTIONS

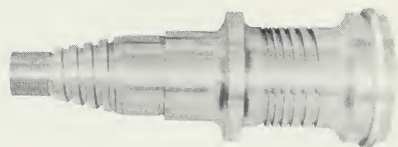
- Permits programming arcs up to 90° with one block of input data
- Feed-rate over-ride capability
- Feed-hold pushbutton stops control without losing synchronization
- Rotary resolver feedback has 0.0001" resolution
- Tape parity and simplified circuit checks provided
- 20 auxiliary functions
- Out-of-synchronization protection

SPECIFICATIONS

SIZES	2413	2514	3220	3220W	4025W	4025	5035	6040	7050
Swing-Over Carriage Wing	25"	25"	32"	33½"	38"	40"	50"	60"	70"
Swing-Over Cross Slide	14"	14"	21"	22"	25"	25"	35"	40"	50"
Base Length Between Centers	54"	48"	48"	48"	48"	60"	60"	60"	60"
Main Drive, 32 to 1 Variable Speed Motor, H.P.	25	20-50	20-50	20-50	20-50	40-75	40-75	40-75	40-75
Taper of Center, Morse Taper Number	4	5	5	6	6	6	6	6	6
Number of Spindle Speed Points Non-overlapping Spindle Speed Points	$\frac{40}{30}$	$\frac{60}{42}$	$\frac{60}{42}$	$\frac{60}{42}$	$\frac{60}{42}$	$\frac{60}{42}$	$\frac{60}{42}$	$\frac{60}{42}$	$\frac{60}{42}$
Range of Spindle Speeds, R.P.M.	27-2000	8-1200	8-1200	8-1200	8-1200	4-600	4-600	2-300	2-300
Length of Carriage on Bed	35"	35"	35"	40"	40"	49"	49"	54"	54"
Number of Feeds (Cross & Long.)	2000	2000	2000	2000	2000	2000	2000	2000	2000
Range of Feeds, Inches per Minute	0.1" to 20"	0.1" to 20"	0.01" to 20"	0.01" to 20"	0.1" to 20"	0.01" to 20"	0.01" to 20"	0.01" to 20"	0.01" to 20"
Minimum Increment of Feed, Inches per Min.	0.1"	0.01"	0.01"	0.01"	0.1"	0.01"	0.01"	0.01"	0.01"
Tool Turret (Square & Hex.) Across Face	8"	8"	8"	10"	10"	12½"	12½"	12½"	12½"
Size of Tool — Width & Height	1" x 1½"	1" x 1½"	1" x 1½"	1½" x 1½"	1½" x 1½"	2" x 2"	2" x 2"	2" x 2"	2" x 2"

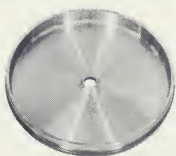
THE PRODUCTS . . .

Aluminum (T-4)



Piece is machined from 19" length and 7" diameter piece of T-4 aluminum. Rough cut 0.625" depth of cut at 450-1000 SFM with 0.0125" IPR. Cycle time—93 minutes.

Turbine Wheel for Jet Engine



Material is AMS 5613, 32-36 Rc. Rough turned at 300 SFM, 0.015" IPR with 0.312" depth of cut. Finished at 500 SFM, 0.005" IPR, with 0.0125" depth of cut. Cycle time—9 minutes.

Rock Bit



Material is 41-40 SAE, 38 Rc when turned. Machined at 520 SFM, with 0.003" to 0.010" IPR, and a 0.015" to 0.020" depth of cut, the cycle time is 9 minutes for both I.D. and O.D. It was previously turned on a Tracer Lathe with a minimum cycle time of 60 minutes. While the Tracer averaged only two parts per set of tools, on the Tape Lathe the average is now four per set of tools.

Test Piece



Material steel SAE 1045, 216 BHN. Two set-ups, threaded-end cycle time 25 minutes, second end 53 minutes. Rough turning was at 250 SFM, 0.020" IPR with ½" depth of cut. Finish turned at 500 SFM, 0.005" IPR. Threads 4 pitch (4" dia.) by 4½" length and second thread 3½" dia. by 11½" length at 25 SFM, .015" depth of cut each pass.

ATW Test Shaft



Material 1045 steel and hardness of 205-225 BHN. Weight of shaft at start 250 lbs. Removed 100 lbs. of metal in 18 minutes. Rough turned at 300 SFM, 0.028" IPR with ⅝" depth of cut. Finished at 400 SFM, 0.010" IPR and 0.0625" depth of cut. Cycle time—18 minutes.

AMERICAN

For more information on the American Tape-controlled Lathe, write to the American Tool Works Co., Pearl and Eggleston Ave., Cincinnati, Ohio.

THE AMERICAN TOOL WORKS COMPANY

Mark Century

For descriptive information on General Electric numerical control systems, write for N/C Data File, GEZ-3774A, Distribution Services, General Electric Company, Schenectady, N. Y.

GENERAL ELECTRIC

Universal Model 6020

Printed Circuit Board Assembly Machine

with General Electric Mark Century* Numerical Control

*Trade-mark of General Electric Co.

speeds assembly up to 50 times, improves quality, reduces costs

Features

- Mark Century N/C with Accupin* position measuring system controls all machine functions for high speeds, low costs.
- Variable depth stop permits inserting components of varying body diameters, provides firm clinching without component damage.
- Multiple board holder eliminates machine downtime to change small or medium-sized boards.
- Component sequence checking assures correct positioning on boards.
- Special cut-and-clinch operation on both leads; or individually to permit extended lead.

Description

The Universal Model 6020 printed circuit board assembly machine is a console for automated board assembly. Control is provided by G-E Mark Century numerical control.

With N/C, the Model 6020 provides dual benefits of cost reduction on high-

volume assembly and versatility on shorter assembly runs. Depending on component and board handling factors, insertion rates of 4500+ parts per hour are possible.

Entire boards may be assembled in one pass with one insertion head—even with components of varying sizes.

An important cost saving stems from the reduction of human error. Checking systems on the 6020 determine when an error is committed and immediately stop the machine. This limits any error to one board.

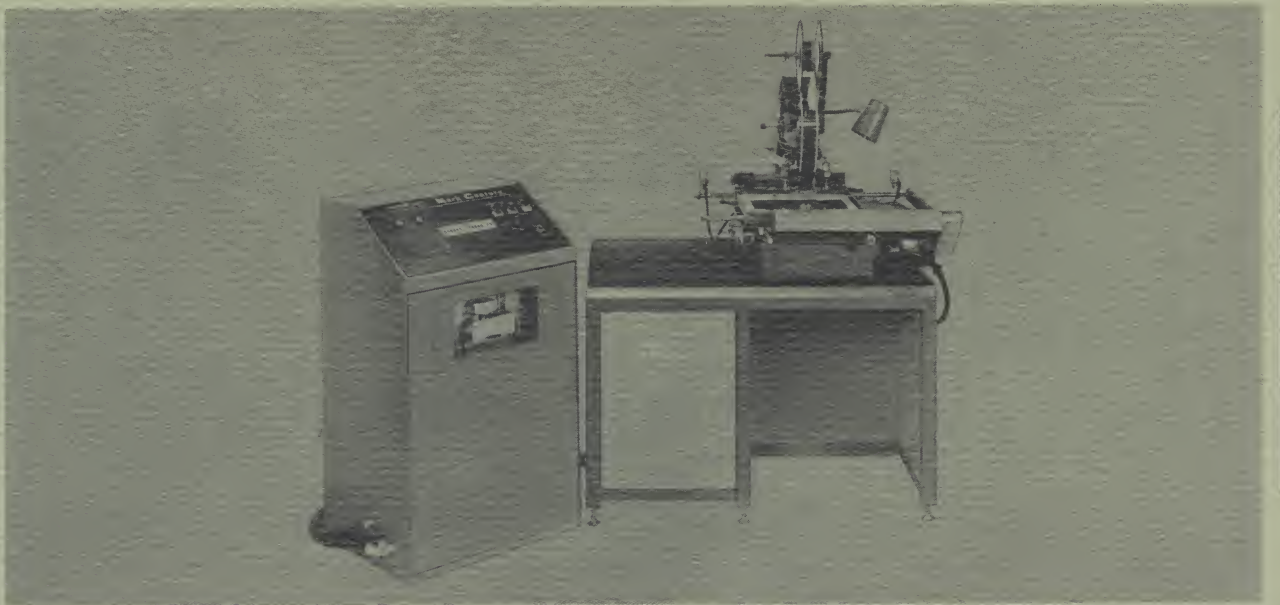
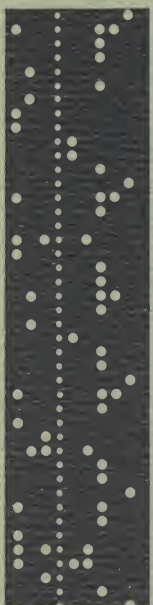
Tape control functions

General Electric's Mark Century numerical control guides all functions of the Model 6020. In addition to positioning the working table with respect to the X and Y axes, the numerical control unit is programmed for insertion control and variations in insertion stroke for components of various sizes.

Equipped with Accupin linear transducer, direct positioning of the insertion head is possible without need for a rack and pinion or lead screw. This eliminates adjustment due to wear.

Components are positioned accurately. High-accuracy resolution permits input measurements as low as 0.0001".

Another example of modernized machining



operation

A programmed tape, which contains the machine's commands, is placed in the Mark Century unit and a circuit board is positioned. Air and power supply are activated by pushing the POWER ON button. With the cycle button in the AUTOMATIC position, programmed operation begins. If a component is missed, the Model 6020 automatically stops to permit the operator to correct any faults. Pressing the RESET button resumes operation.

sequence checking

Proper component sequence is checked by the Model 6020 at the start of each new board by noting a preset space between groups of lead taped components. If the sequence becomes incorrect during operation, it is immediately detected by the machine which automatically goes on hold, limiting any error to one board.



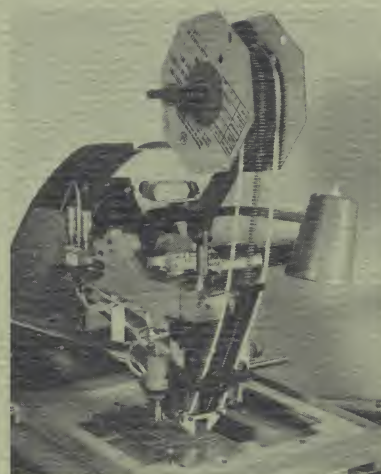
variable-depth stop

To insert components of varying sizes in sequence, four buttons (more optional) in the depth stop can be set at varying heights which will, in turn, control insertion depth. This control provides extra versatility while assuring tight clinching on component leads without component body damage.



multi-board holder

If medium or small boards are used, multiple board locations are possible on the holder. This permits removing assembled boards and replacing with blank boards without disrupting operations.



savings

Here's an example of savings you can get. The printed circuit board (shown above) requires 39 components of 11 different parts. Assume 5000 boards per month, direct labor \$2.50 per hour, overhead at \$3.75 per hour, and use of a Universal Model 4015 sequencer and a Model 6020 insertion machine equipped with Mark Century numerical control.

A cost analysis shows:

Hand assembly, cost per board	\$ 1.18
Automatic assembly cost per board	0.05
Gross savings, first year	67,800.00
Total equipment cost	50,500.00
Net savings, first year	17,300.00

Subsequent annual savings will be \$67,800, since all equipment is amortized within the first year.

Numerically controlled insertion machines are also available for integrated circuit modules, transistors, jumper wires, and miniature axial lead components.



Instruments Corporation
East Frederick Street
Binghamton, N.Y. 13902
Tel: 607-772-1710
TWX: 510-252-1990

For complete information,
write for:
Bulletin 6000A—
Labor-saving Component
Insertion Systems
Bulletin 4000—
Labor-saving Component
Sequencing

Mark
Century

GENERAL  ELECTRIC

For descriptive information on G-E numerical control systems, write for N/C DATA FILE, GEZ-3774, Distribution Services, General Electric Co., Schenectady, N.Y. 12305.

Olofsson Contour-O-Matic

with General Electric Mark Century* Numerical Control

*Trademark of General Electric Co.

**precision turning, facing, boring, chamfering
and contouring with least number of tools**

FEATURES

- Double end
- 4 spindles
- D-c spindle drive, 40 speeds with dynamic braking and reversing
- 8 tool offsets
- Feed rates infinitely variable from $\frac{1}{4}$ to 150 ipm
- Less than 0.0001 in. electrical repeat accuracy
- SCR table drive motors (d-c)
- All electric, no hydraulics
- Solid-state controls
- Accepts standard, 8-channel E.I.A. tape
- Can be programmed without computers
- Precision anti-friction bearing ways
- Precision ball screws and anti-backlash ball nuts

DESCRIPTION

Olofsson's four-spindle, precision double-end chucking machine with Mark Century 100S N/C is extremely accurate and versatile.

Designed to finish parts that can be rotated, the Countour-O-Matic

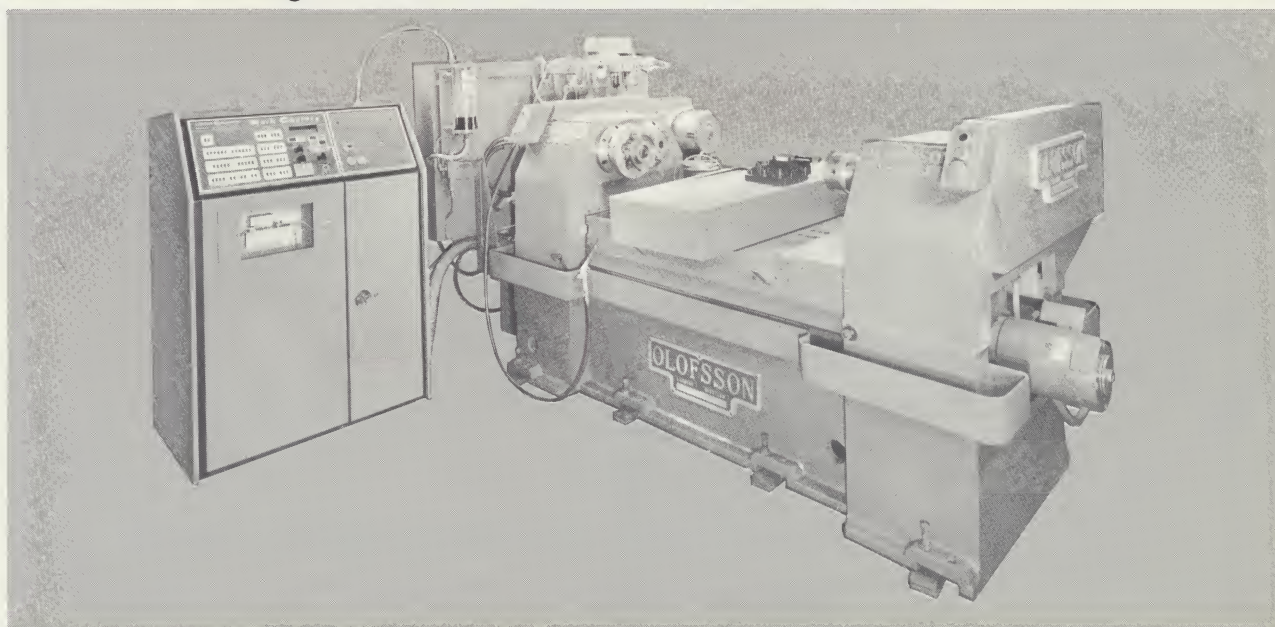
maintains exacting tolerances with the least number of tools. One tool can be used to bore, face, turn, and generate chamfers and contours. Turning and boring on the same part with one tool can be done by spindle reversal, which can be called for by tape command.

With four spindles available, many holding devices can be used. For example, one spindle could be equipped with an international chuck, another with an external chuck. The third could be equipped with a collet adapter with a wide range of collets. And the fourth could have a diaphragm-type chuck of large diameters.

A wide range of spindles is available — from heavy-duty (equipped with roller bearings) to a high-speed spindle with ball bearings. These spindles are round body, quill type and can be easily removed.

The spindle drive is d-c with dynamic braking and reversing. It can be started, stopped, and reversed by tape command and can be programmed for 40 different spindle speeds.

Another example of modernized machining



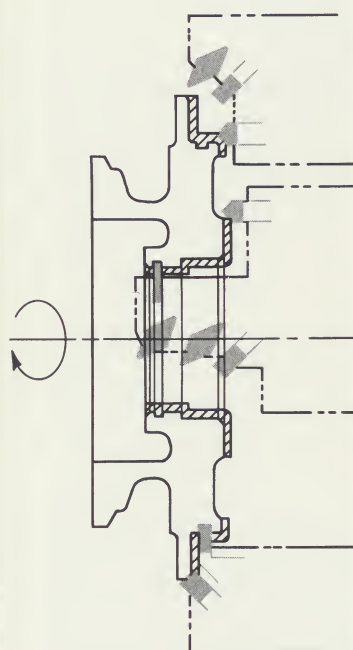
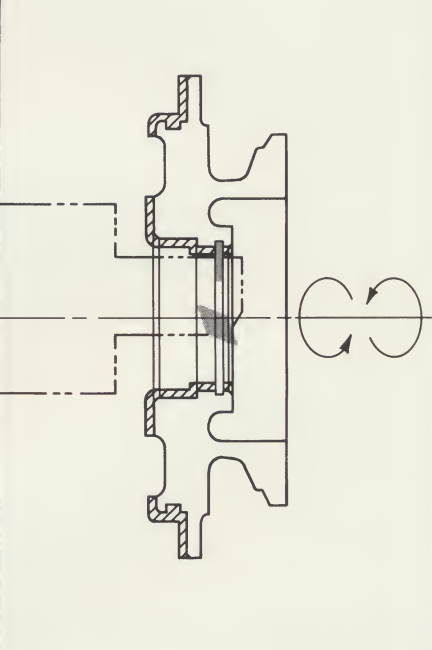
specifications

NUMERICAL CONTROL FUNCTIONS

- Full circular interpolation permits programming arcs up to 90° with a single block of input data.
- Up to 40 different spindle speeds may be programmed.
- Four pairs of tool zero offsets provide a precise method of setting the cutting edge of the tool.
- For use in two axes, ± 0.0099 in. Any pair of off-sets may be tape selected for any tool.
- Feed-rate over-ride from 0 to 100% of programmed value.
- Feed-hold pushbutton stops the control at any time without losing synchronization. Machine resumes normal operation when button is released.

Number of axes	2
X-axis travel	10"
Z-axis travel	24"
Swing	20" dia.
Table drives, $\frac{3}{4}$ H.P. d-c, SCR	1 per axis
Positioning speeds	$\frac{1}{4}$ to 150 ipm
Contouring speeds	15 ipm max.
Position repeatability	± 0.0001 "

machine comparison

	CONVENTIONAL		CONTOUR-O-MATIC
	\$2800	Tooling costs	\$250
	10	# of tools needed	2
	120 hr. approx.	Tooling design time	None
	10	# tools to adjust	2
	hours	Part change	Tape change
	Reset stops, switches, dogs	Changeover	Nothing to reset
	2	# spindle speeds	40
	2	# feed rates	Infinite between $\frac{1}{4}$ to 150 ipm
	Slight burrs left	Chamfer quality	No burrs
	1 box: 1' x 1' x 8"	Tool storage	1 box: 2" x 2" x 6"
	± 0.0005 "	Tolerance	± 0.0001 "
			

LOFSSON
CORPORATION

For more information on the new CONTOUR-O-MATIC four-spindle, precision double-end chucking machine write Olofsson Corporation, 2727 Lyons Avenue, Lansing, Mich.

Mark
Century

GENERAL ELECTRIC

For descriptive information on G-E numerical control systems, write for N/C DATA FILE, GEZ-3744, Distribution Services, General Electric Company, Schenectady, N.Y.

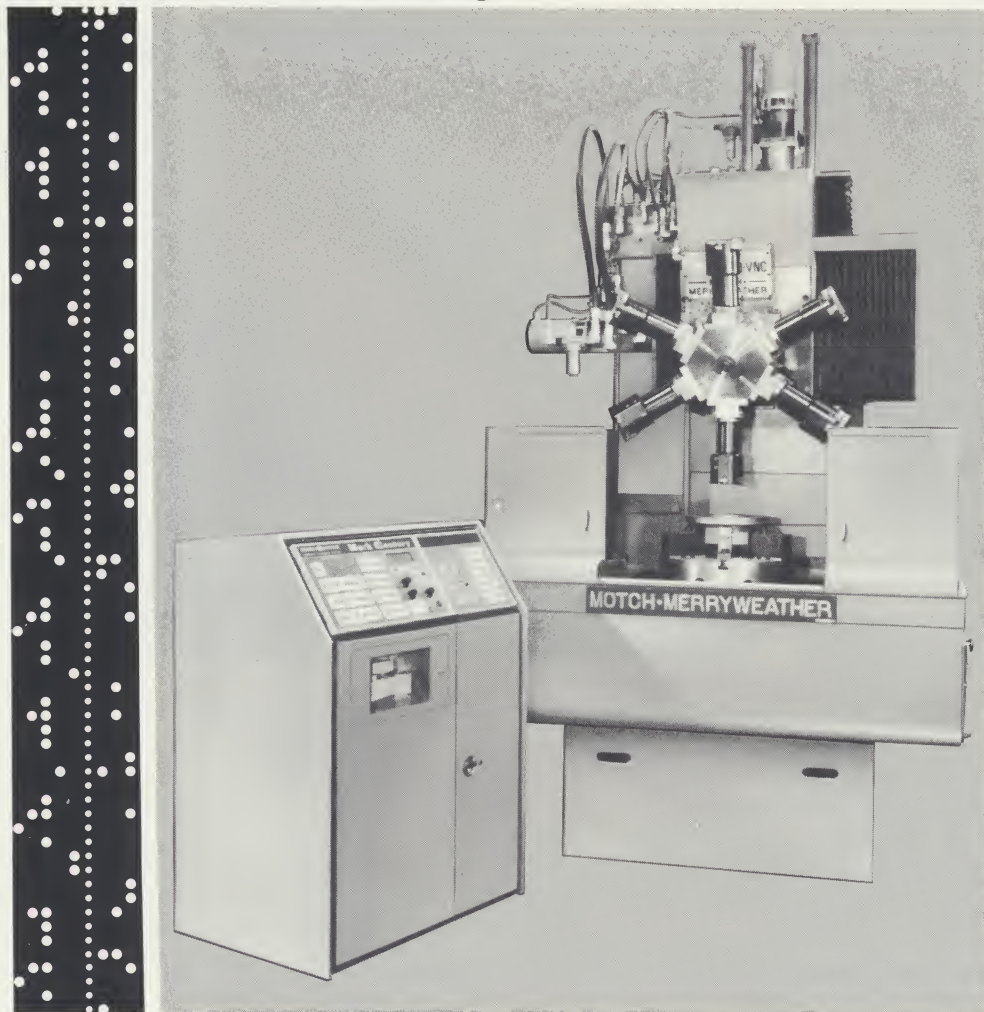
Notch and Merryweather model 21-VNC vertical chucker with General Electric Mark Century* Numerical Control for accurate and versatile machining of parts in small lots

*Trademark of General Electric Company.

FEATURES

- Great machining capacity for a wide range of operations.
- Simplified standard tooling for low-set-up-time short runs at high production savings.
- Vertical construction design for minimum floor space and maximum accessibility.
- Tape commands X and Z axis for simultaneous operation.

Another example of modernized machining



DESCRIPTION

The Notch and Merryweather Model 21-VNC vertical chucking machine, equipped with General Electric Mark Century 100S Numerical Control, is a fully automatic production center. Designed for fast and accurate machining of short-run parts, the Model 21-VNC is capable of multiple-pass turning, boring, and facing, and I.D. — O.D. grooving, contouring, and tapering work. The Model 21-VNC performs threading operations with collapsible taps or self-opening die heads, solid taps, and single-point tools.

Rugged construction of the Model 21-VNC makes possible continuous operating schedules — even with heavy-duty work loads. Precision alignment with tool offsets results in accurate, versatile machining for short-run operations.

Preset tooling standards on the Model 21-VNC — Mark Century N/C combination minimize setup time and reduce change-over time to a low of 10-25 minutes.

Automatic operation with tape control helps assure high quality and low cost regardless of operator experience.

CONTROL FUNCTIONS

- Three modes of operation for maximum versatility — automatic, semi-automatic or manual.
- Maximum tool selection — up to nine variations for greater flexibility (only six required on M&M 21-VNC).
- Variable spindle-speed selection — as many as sixty (twelve per setup) for a variety of operations and commands.

Specifications

Slide

Vertical movement Z axis.....18"
 Horizontal movement X axis.....2" to left,
 13" to right of center line for total of 15"
 Feed rate.....up to 20" per minute
 Traverse rate.....up to 200" per minute
 Turrets available.....6 stations
 Swing-over-way guards.....24" diameter
 Machining capacity.....up to 20" diameter x 12" high

Spindle

Drive motor.....40/20 hp, 900/1800 rpm
 Type.....heavy duty, A2-11" worm
 drive with change gears
 Speeds.....5 ranges, 14 to 700 rpm

Gear

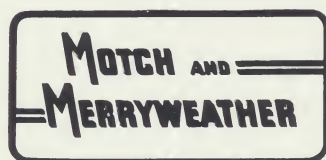
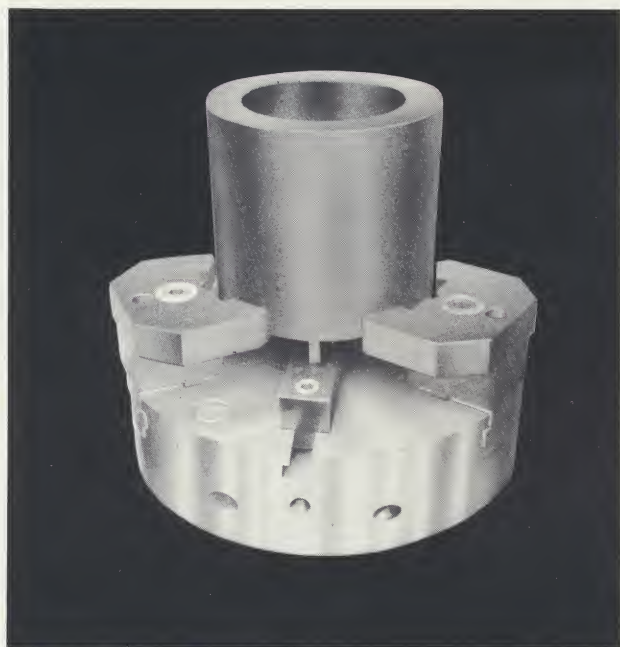
Hp rating.....50 hp
 (automatic gear box)
 Pick-off gears.....3 sets
 Ranges.....5 (tape
 selects 12 speeds each range)

Hydraulic unit with filter and water-cooled heat exchanger

.....separate 20 hp motor
Turret location.....6 station (by curvic coupling)
Tooling.....standard, preset, quick-change type
Machine floor space....95" wide, 151" long, 134" high
Total shipping weight (approx.).....18,000 lbs.
Tape reading speed...120 characters per sec. on Mod II
 300 characters per sec. on Mod III
Tape format.....EIA — word address

Savings

Shown at start and finish of operation, this part was machined in 18 minutes with Model 21-VNC. Manual mode required 3 hours. Machining accuracy measured to 0.0005" radius.



MOTCH & MERRYWEATHER

For more information on the Model 21-VNC, write to Motch & Merryweather Machinery Company, Machine Tool Manufacturing Division, 1250 E. 222 St., Cleveland, Ohio 44117.

**Mark
100 Century**

GENERAL  ELECTRIC

For descriptive information on General Electric numerical control systems, write for N/C DATA FILE GEZ-3774, Distribution Services, General Electric Company, Schenectady, N. Y. 12305.

Kearney & Trecker

3-axis MILWAUKEE-MATIC® Series Eb

with General Electric Mark Century* Numerical Control

* Trademark of General Electric Company ® Registered Trademark of Kearney & Trecker Corporation

... automates small-lot production

FEATURES

- Exclusive pre-set tool magazine for automatic sequential tool selection
- Four-position index table for single setup, four-side machining
- Axial retention device eliminates tool holder pull-out during machining
- Universal fixture kit for reduced work-holding costs
- Jig bore principle applied to spindle-head (Y-axis) for built-in precision

DESCRIPTION

The Kearney & Trecker 3-axis MILWAUKEE-MATIC Series Eb, equipped with General Electric Mark Century numerical control, is a multiple-operation machining center designed for small-lot production runs.

For maximum versatility and fast tool changing, the Series Eb has an exclusive rotary magazine system which accommodates up to fifteen tools — each on call in series within five sec-

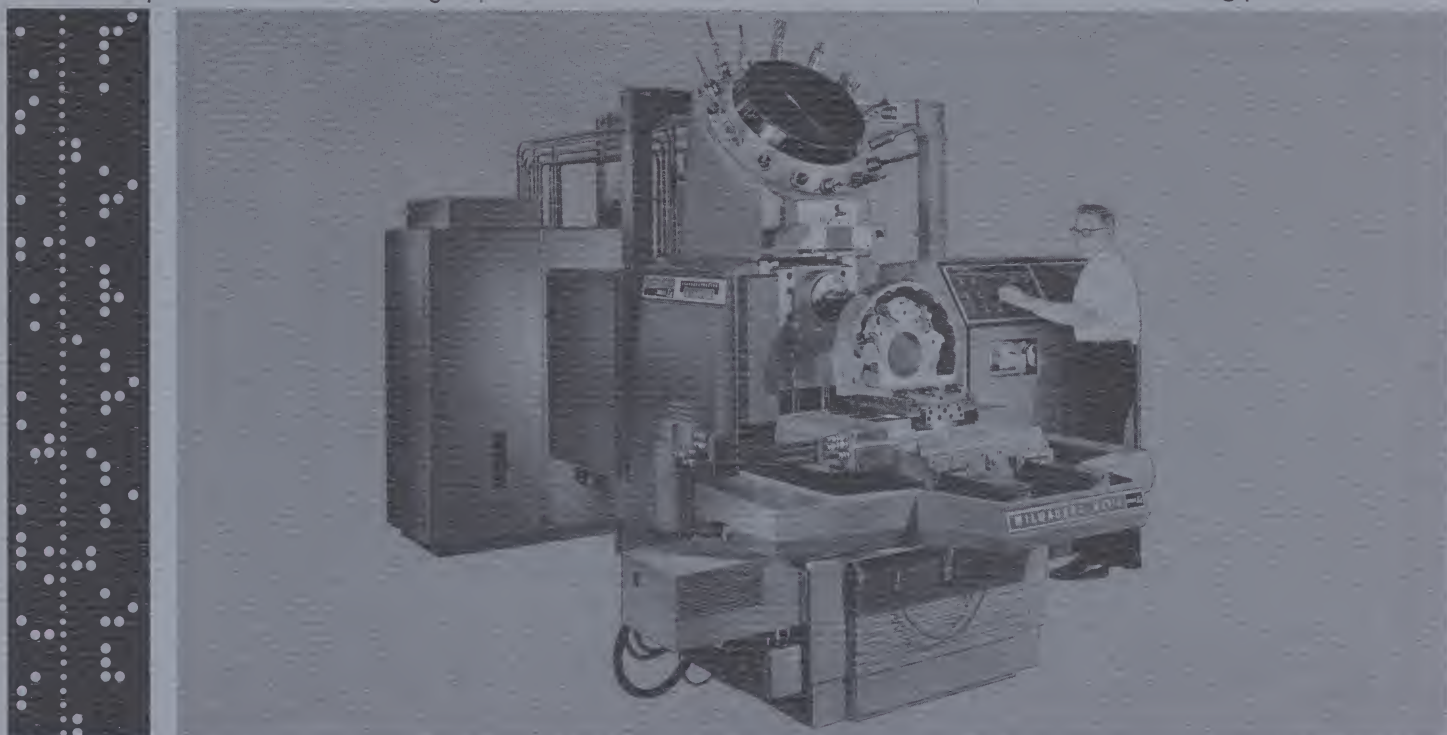
onds. To change tools, the Series Eb changer arm removes a tool from the spindle and returns it to the rotary storage magazine while simultaneously inserting the next tool in the machine spindle.

An axial retention lock, built into the spindle, eliminates tool holder pull-out during machining operations — even with spiral cutters.

To permit preset four-side machining, a multi-position, 16" diameter table can be automatically indexed to four 90° angle positions. The table is equipped with edge locators to enable rapid part positioning and securing.

The General Electric Mark Century numerical control accepts standard one inch, 8-channel punched tape. Programs can be prepared on a standard office tape machine or with the use of a computer. Programming is simple and can be handled by anyone familiar with the MILWAUKEE-MATIC Series Eb after a brief training period.

Another example of modernized machining



Specifications

Slide movements —

positioning accuracy, commercial — $\pm 0.001"$

positioning accuracy, precision — $\pm 0.0005"$

Saddle — longitudinal (X) axis.....24"

Spindle head — vertical (Y) axis.....16"

Table — depth (Z) axis.....16"

Work surface — 4-position index table.....dia. 16"

Weight capacity (workpiece and fixture).....1,000 lbs.

Feed — all linear axes.....0.1 thru 98 ipm

Contouring (X & Y axes) optional.....max. 50 ipm

Rapid traverse.....200 ipm

Programmed feed rate may be reduced by 100% in 10% steps by a feed rate override.

Spindle speeds.....100 to 3000 rpm

Spindle drive motor — hydraulic.....5 hp
(5 hp constant output)

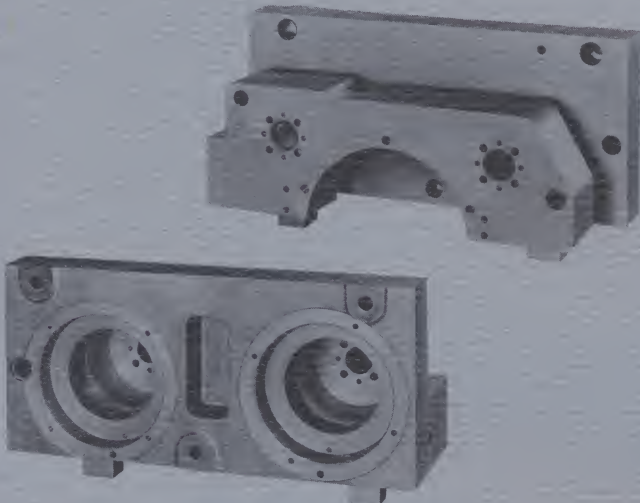
Control system...G-E Mark Century, 100% solid-state control

Tape reader — photoelectric...300 characters/second

Tape format — binary coded decimal, letter address, 1" wide, 8-channel.

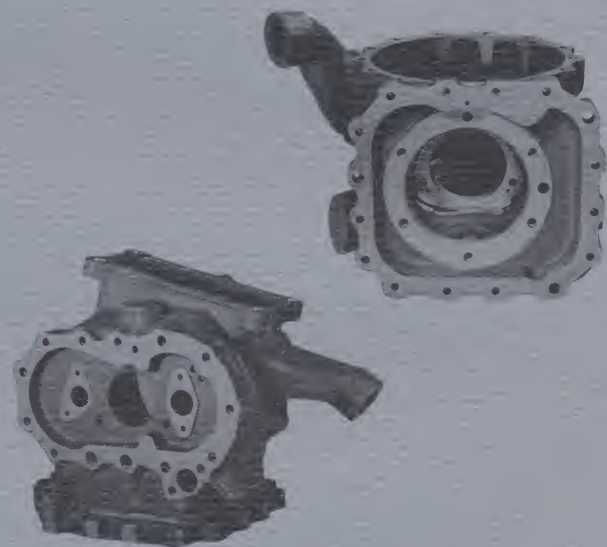
The savings

Listed below are cost comparisons between two sets of identical parts — one machined with the MILWAUKEE-MATIC Series Eb, the other with a conventional unit. Parts were machined complete, including contouring.



Material — aluminum, Lot size — 30,
Six sides worked in two setups

	Conventional	MILWAUKEE-MATIC Eb
Setup	8.6 hours	0.5 hours
Cycle	5.8 hours	1.1 hours
Tooling	\$9,600.00	\$1,700.00



Material — magnesium, Lot size — 20,
Seven sides worked in two setups

	Conventional	MILWAUKEE-MATIC Eb
Setup	17.8 hours	0.5 hours
Cycle	6.5 hours	1.7 hours
Tooling	\$9,500.00	\$1,450.00

Savings shown result from the MILWAUKEE-MATIC's one-unit multiple-operation design, automatic tool changing and pre-set tooling, and four-position table indexing.



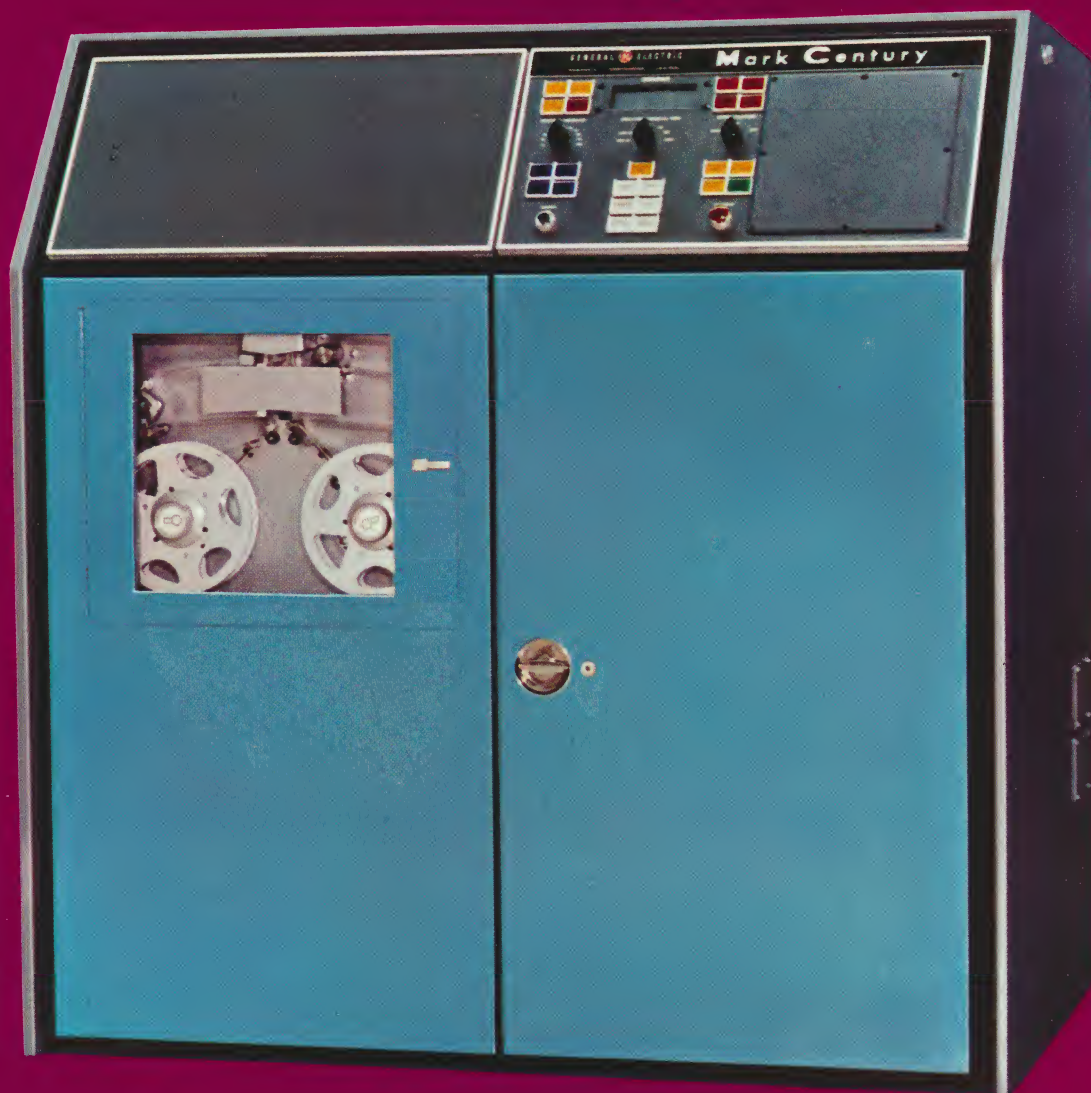
**KEARNEY & TRECKER
CORPORATION**

For more information on MILWAUKEE-MATIC machine tools, write to Kearney & Trecker Corporation, Milwaukee, Wisconsin 53214.

**Mark
Century**

GENERAL  ELECTRIC

For descriptive information on General Electric numerical control systems, write for N/C DATA FILE, GEZ-3774, Distribution Services, General Electric Company, Schenectady, New York 12305



Mark Century* 100M

Numerical Contour Milling Control

A packaged Mark Century 3-motion numerical control
for continuous-path milling machines

GENERAL  ELECTRIC



Mark Century 100M

numerical contour milling control

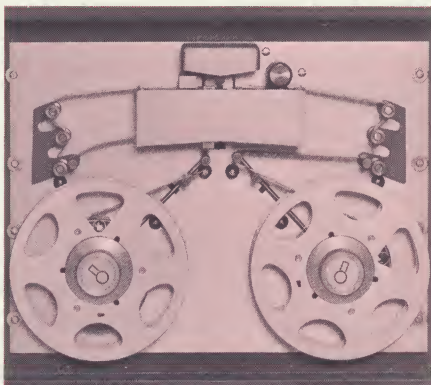
easily justified in any plant...

With the Mark Century 100M numerical control you get high performance contour milling at low cost—thanks to GE's unique concept, "packaged design."

Like other GE packaged models, the 100M control comes in one basic design with a choice of pre-engineered options for added flexibility. You save through product standardization and pay only for features you need.

What's more, all GE packaged numerical controls are similar in design and construction. This means operating costs drop where several types are in use because training and maintenance expenses are less and overall operating efficiency improves.

Besides the 100M control, GE has Mark Century packaged systems for turning, profile milling, boring, and point-to-point operations. They're available on a wide range of machines from a great number of machine builders.



High-speed photoelectric tape reader—500 characters per second—is an optional feature.

Highly reliable

The Mark Century 100M packaged control is built to the same high standards of design and construction as Mark Century custom controls. High reliability of the 100M control is the result of more than a decade of General Electric experience in supplying thousands of numerical control systems to over 100 machine tool manufacturers.

The Mark Century 100M numerical control is a digital system which takes full advantage of the fully proved reliability of transistorized printed circuits. Input data is entirely distributed, stored, and acted upon by solid-state circuitry.

Materials, fabrication methods, and components are used which meet rugged industrial requirements. For example, cabinet steel is heavy gauge, all wire connections are wrapped instead of soldered, and the latest design miniaturized operator devices are used. The enclosure is a NEMA 1 pressure ventilated, floor-mounted unit.

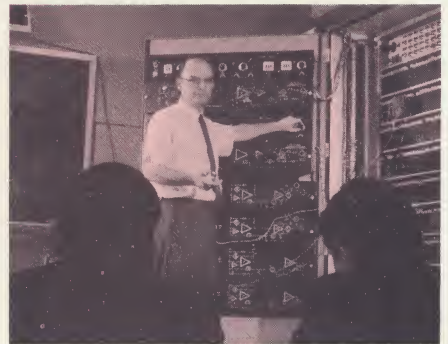
And, installation and start-up at your plant is quick and easy because the Mark Century 100M control is carefully matched to each builder's machine before it reaches you.

Total service

To help your personnel care for the Mark Century 100M control after installation and start-up, a two-week maintenance training school is conducted at the General Electric factory.

And this is just the beginning. General Electric provides the most complete service package in the industry today. Other services include:

- Automatic check tape for logic circuits
- Unmatched product warranties
- Local stocks of replacement parts
- Complete service and instruction manuals
- Printed circuit board exchange program
- Computer software support
- Local service engineers on call 24 hours a day for world-wide maintenance service.



GE training school educates your maintenance personnel in the care of your Mark Century 100M control.

for 3-motion continuous path milling

The Mark Century 100M contouring system can simultaneously control three machine motions, and is specially designed for machines doing contour milling on two- and three-dimensional shapes.

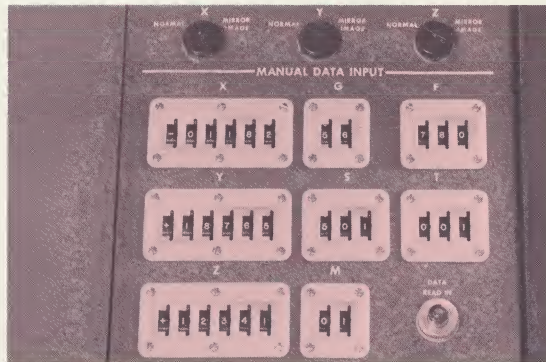
Convenience engineered

The 100M control is human engineered with switches and push buttons functionally arranged on a sloping panel across the top-front of the unit. Swing-open gasketed doors front, back, and top provide easy access to all parts of the unit. And interior walls are painted white for maximum visibility.

The logic-circuit portion of the control system is functionally arranged in modular panels of plug-in printed circuit boards. To make board changing easy and foolproof both the boards and rack slots are identified by function code.

The compact Mark Century 100M control measures only 52-inches wide, 32-inches deep, and 54-inches high.

Full manual input capability using thumb-wheel switches is standard.



Simplified programming

To make programming and maintenance easier, the Mark Century 100M control has a binary-coded decimal format using standard EIA, 8-channel punched tape. The data are read by a photoelectric tape reader that operates at a speed of 300 characters per second. A 500 cps reader is available as an option. The control may also be operated by full manual data input or by jog push buttons for each motion.

To further simplify programming, postprocessors for APT and ADAPT computer programs are available.

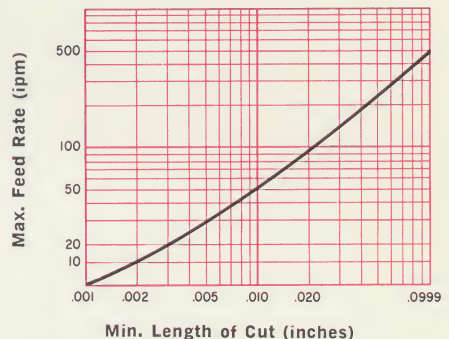
The Mark Century 100M control has full 5-digit command capability, accepts incremental commands, has buffer storage, and is a linear interpolation system. Straight cuts and slopes up to 9.999 inches can be programmed in each of three motions in the G01 mode. Dimensions up to 99.999 inches may be programmed with the G10 departure command.

Electrical resolution is ± 0.0001 inch, with absolute control positioning accuracy of ± 0.0004 inch, based on standard machine conditions.

Unique milling capabilities

The Mark Century 100M is specifically a contour milling control system. The features you need are designed-in.

Full five digit command capability and long, normal, short, and extra-short block multipliers simplify programming and improve contouring performance. And, with the 100M control's extra-short block execution multipliers you can mill extremely short departures at high feed rates.

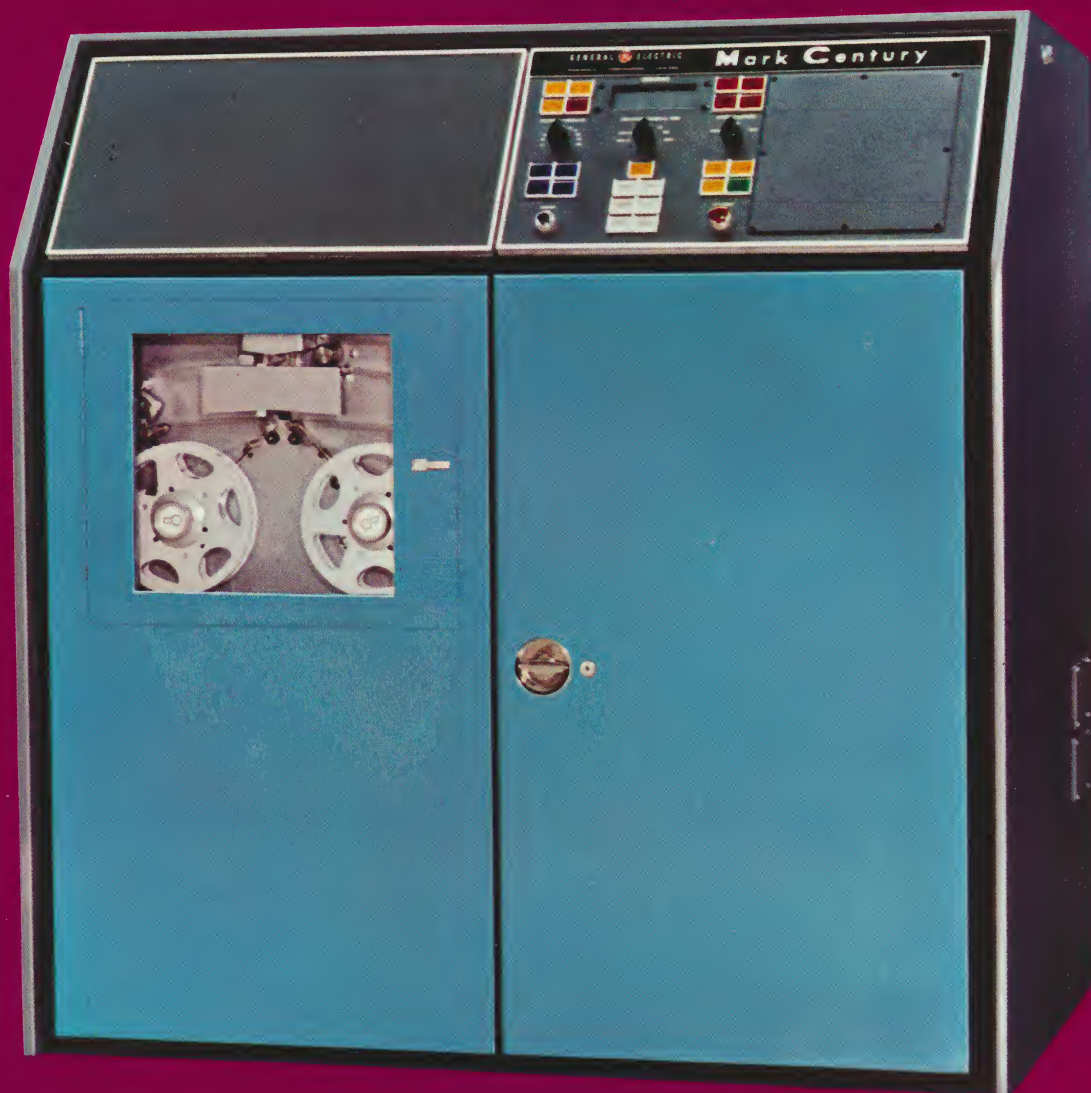


High feed rates for short departures with the Mark Century 100M control.

GE's outstanding electrohydraulic or SCR electronic servo systems offer you the industry's best performance. You get high accuracy, smoother finishes and minimum machine wear.

Your programmer does not have to worry about overshoot. Both inside and outside corners may be executed without programming deceleration or acceleration. GE's unique servo application does the work.

The GE double feedback system—both position and velocity loop—gives you the machine-control response needed for maximum milling efficiency.



Mark Century* 100M

Numerical Contour Milling Control

A packaged Mark Century 3-motion numerical control
for continuous-path milling machines

GENERAL  ELECTRIC



Mark Century 100M

numerical contour milling control

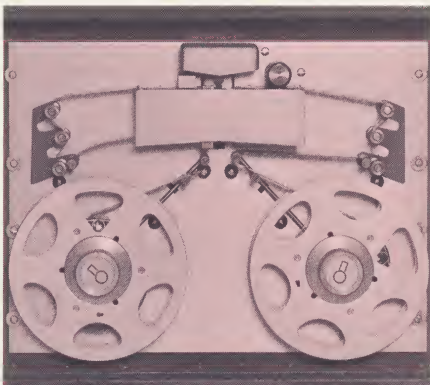
easily justified in any plant...

With the Mark Century 100M numerical control you get high performance contour milling at low cost—thanks to GE's unique concept, "packaged design."

Like other GE packaged models, the 100M control comes in one basic design with a choice of pre-engineered options for added flexibility. You save through product standardization and pay only for features you need.

What's more, all GE packaged numerical controls are similar in design and construction. This means operating costs drop where several types are in use because training and maintenance expenses are less and overall operating efficiency improves.

Besides the 100M control, GE has Mark Century packaged systems for turning, profile milling, boring, and point-to-point operations. They're available on a wide range of machines from a great number of machine builders.



High-speed photoelectric tape reader—500 characters per second—is an optional feature.

Highly reliable

The Mark Century 100M packaged control is built to the same high standards of design and construction as Mark Century custom controls. High reliability of the 100M control is the result of more than a decade of General Electric experience in supplying thousands of numerical control systems to over 100 machine tool manufacturers.

The Mark Century 100M numerical control is a digital system which takes full advantage of the fully proved reliability of transistorized printed circuits. Input data is entirely distributed, stored, and acted upon by solid-state circuitry.

Materials, fabrication methods, and components are used which meet rugged industrial requirements. For example, cabinet steel is heavy gauge, all wire connections are wrapped instead of soldered, and the latest design miniaturized operator devices are used. The enclosure is a NEMA 1 pressure ventilated, floor-mounted unit.

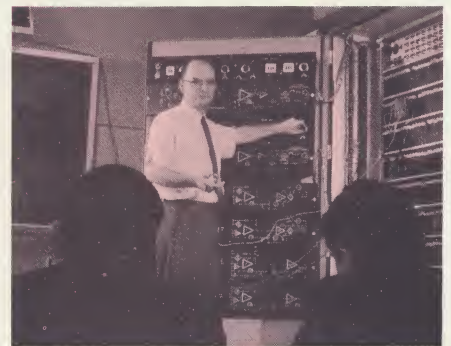
And, installation and start-up at your plant is quick and easy because the Mark Century 100M control is carefully matched to each builder's machine before it reaches you.

Total service

To help your personnel care for the Mark Century 100M control after installation and start-up, a two-week maintenance training school is conducted at the General Electric factory.

And this is just the beginning. General Electric provides the most complete service package in the industry today. Other services include:

- Automatic check tape for logic circuits
- Unmatched product warranties
- Local stocks of replacement parts
- Complete service and instruction manuals
- Printed circuit board exchange program
- Computer software support
- Local service engineers on call 24 hours a day for world-wide maintenance service.



GE training school educates your maintenance personnel in the care of your Mark Century 100M control.

for 3-motion continuous path milling

The Mark Century 100M contouring system can simultaneously control three machine motions, and is specially designed for machines doing contour milling on two- and three-dimensional shapes.

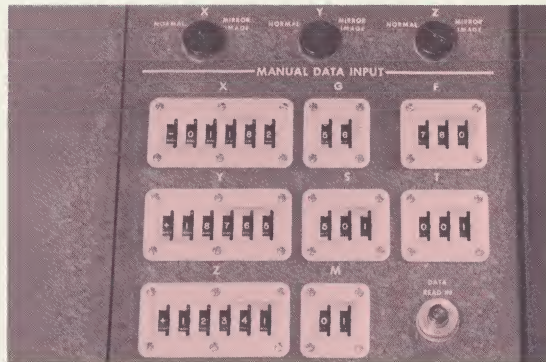
Convenience engineered

The 100M control is human engineered with switches and push buttons functionally arranged on a sloping panel across the top-front of the unit. Swing-open gasketed doors front, back, and top provide easy access to all parts of the unit. And interior walls are painted white for maximum visibility.

The logic-circuit portion of the control system is functionally arranged in modular panels of plug-in printed circuit boards. To make board changing easy and foolproof both the boards and rack slots are identified by function code.

The compact Mark Century 100M control measures only 52-inches wide, 32-inches deep, and 54-inches high.

Full manual input capability using thumb-wheel switches is standard.



Simplified programming

To make programming and maintenance easier, the Mark Century 100M control has a binary-coded decimal format using standard EIA, 8-channel punched tape. The data are read by a photoelectric tape reader that operates at a speed of 300 characters per second. A 500 cps reader is available as an option. The control may also be operated by full manual data input or by jog push buttons for each motion.

To further simplify programming, postprocessors for APT and ADAPT computer programs are available.

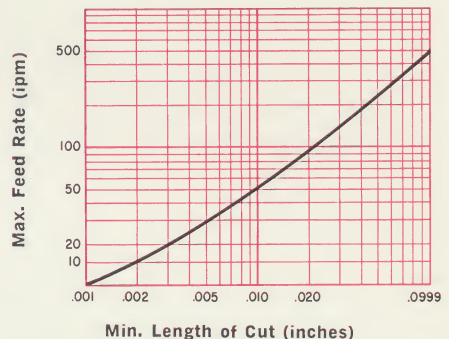
The Mark Century 100M control has full 5-digit command capability, accepts incremental commands, has buffer storage, and is a linear interpolation system. Straight cuts and slopes up to 9.9999 inches can be programmed in each of three motions in the G01 mode. Dimensions up to 99.999 inches may be programmed with the G10 departure command.

Electrical resolution is ± 0.0001 inch, with absolute control positioning accuracy of ± 0.0004 inch, based on standard machine conditions.

Unique milling capabilities

The Mark Century 100M is specifically a contour milling control system. The features you need are designed-in.

Full five digit command capability and long, normal, short, and extra-short block multipliers simplify programming and improve contouring performance. And, with the 100M control's extra-short block execution multipliers you can mill extremely short departures at high feed rates.



High feed rates for short departures with the Mark Century 100M control.

GE's outstanding electrohydraulic or SCR electronic servo systems offer you the industry's best performance. You get high accuracy, smoother finishes and minimum machine wear.

Your programmer does not have to worry about overshoot. Both inside and outside corners may be executed without programming deceleration or acceleration. GE's unique servo application does the work.

The GE double feedback system—both position and velocity loop—gives you the machine-control response needed for maximum milling efficiency.



Mark Century 100M

numerical contour milling control

Standard Features

High-speed Reader—A high-speed, 300-characters per second photoelectric tape reader is provided.

Full Manual Data Input—All data necessary for full machine operation can be input by thumbwheel switches. This is a valuable aid in set-up, initial program checkout, maintenance, and prototype work.

Incremental Feed Switch—For precise manual operation, movement of a selected increment from 0.0001 to 1.0 inch can be made by setting the selector switch for that increment and pressing the appropriate axis pushbutton.

Jogging Mode—Rapid manual movements can be made as needed for set-up and maintenance. Depressing one or more of the axis pushbuttons with the selector switch in **JOG** produces motion in either the plus or minus direction at a selected feedrate until the button is released.

Sequence Number Readout—This display identifies the tape command being acted upon by the machine, enabling the operator to search out any particular program sequence.

Miscellaneous Functions—As many as 100 miscellaneous commands may be utilized to control coolant flow and clutch circuits, to determine spindle direction and gear changing, and to permit more automatic control of the machining process.

Spindle Speed Selection—Up to 100 different spindle speeds may be programmed for maximum flexibility. "S" commands from 00 to 99 are available as needed.

Feedrate Override—For capability from 0 to 100 percent of programmed value, the operator can vary programmed feedrate at will by a Selector Switch.

Feedhold Push Button—A latching push button allows the operator to stop the control at any time without losing synchronization, even when the control is processing a block of information. The machine resumes normal operation when the button is depressed again.

Machine Mode Selector—The Mark Century 100M control can be operated in these modes:

Automatic—All machine commands come from programmed tape.

Semi-Automatic—Machine operated from commands entered by operator on the manual-data-input panel.

Manual—Operator may direct motions of machine by push button control of each axis.

Zero-position Push Buttons—Depressing these buttons for each axis sets all control counters to the zero dimension and causes the respective controlled motions to operate at top feedrate to their respective zero limit switches. At this point, the machine is synchronized and ready to start a contouring cycle.

Tape Parity Check—Reading error or parity check of each character read from the tape is provided. A tape error will stop all motions at the last command and illuminate a "reading error" light.

Sprocket Hole Verification—Proper alignment is also verified by a sprocket hole check circuit.

Parity Override—To allow for tape identification on the leader, the reader ignores everything prior to an end-of-block code.

Out of Synchronism Protection—Automatic acceleration limit circuit prevents the difference between commanded and actual positions from exceeding a predetermined amount.

Overtemperature Protection—This feature warns the operator of an overtemperature condition in the enclosure.

Rotary Resolver Feedback Unit—Precise correspondence of command signal and machine member is provided to a resolution of 0.0001 inch.

Servo Drives—Solid-state hydraulic servo systems are standard, providing highly reliable operation and maximum accuracy.

Control Checkout—The logic circuitry can be completely checked for proper operation by means of automatic check tapes.

Mirror Image—Axis inversion switches allow both right and left-hand parts to be produced from one tape by reversing the sign of the departures.

Optional features

Several optional features are provided for those applications requiring the special capabilities of each. They can be added easily with plug-in units and minor rewiring.

High-Speed Reader—For greater feedrate flexibility in programming short departures, a high-speed 500 character per second photoelectric tape reader is available with 8½ inch reels.

Full Floating Zero—Differential resolvers may be used to allow the programmer to establish his zero reference point at any desired location on the machine.

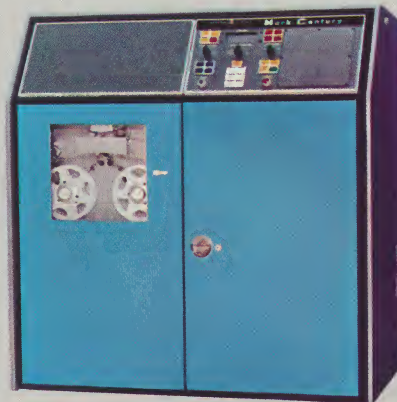
SCR Electronic Drives—Solid-state SCR (silicon-controlled rectifier) servo systems are available for greater flexibility.

Accupin* Linear Transducer—Direct measurement of the machine-tool position independent of lead screws or rack and pinion. Any mechanical inaccuracies in lead screws, gearing, and drive system are by-passed.

Third Digit "S"—A third digit of spindle speed capability may be added if needed.

Tool Selection—Either one, two, or three-digit "t" code provisions may be added.

*Trademark of General Electric Company



There is a Mark Century numerical control system to fit your needs, whatever your performance requirements. See your GE Sales Engineer, or machine-tool builder's representative for more information about General Electric numerical controls including the new Mark Century 100M control.

Specialty Control Department, Waynesboro, Virginia

GENERAL  ELECTRIC

Burgmaster

20T-SH 20-spindle machining center

with General Electric Mark Century* Numerical Control

*Trademark of General Electric Company

... for accurate machining of large, heavy pieces

FEATURES

- Any spindle can drill, tap, mill, or bore for added flexibility.
- Four heavy-duty milling spindles with automatic quill clamps easily handle heavy work pieces.
- Tools never leave the spindles, quills never leave the carrier so dirt and chips don't interfere with tool placement or destroy accuracy.
- Sliding-head construction increases work room over the table.

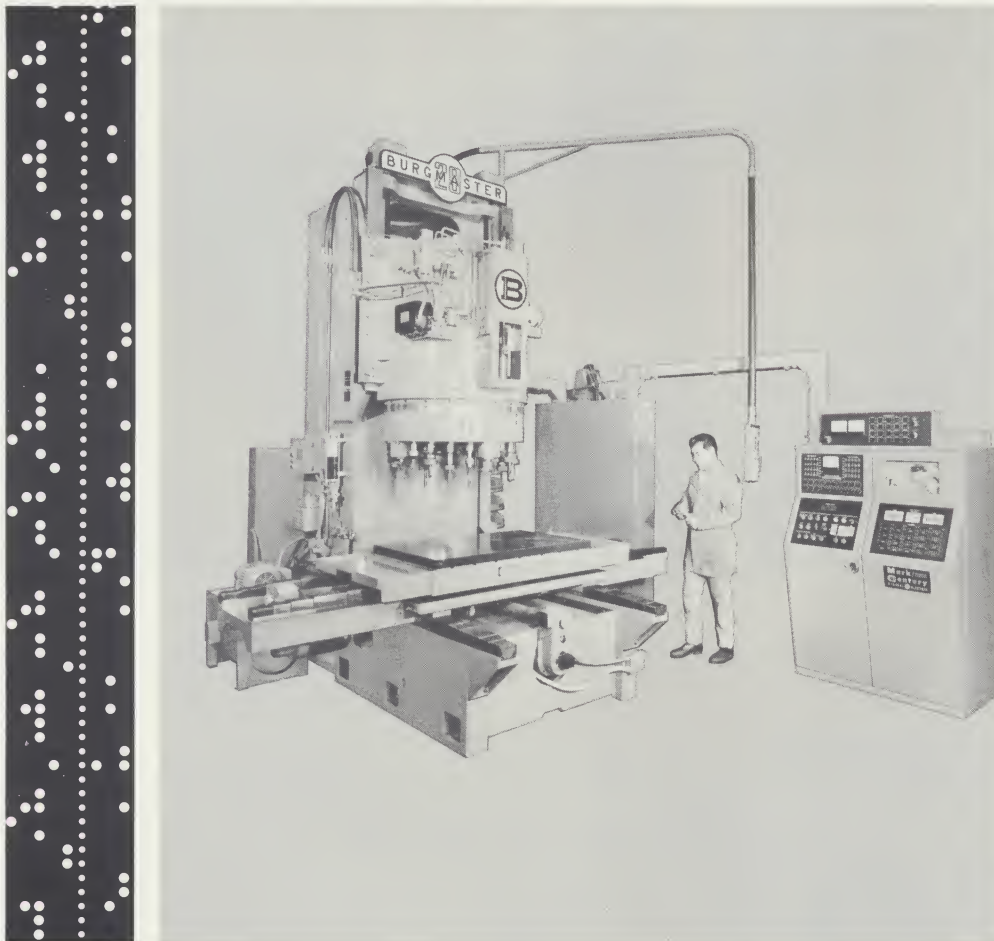
DESCRIPTION

The Burgmaster 20T-SH machine, equipped with General Electric Mark Century Numerical Control, is a complete machining center. The heavy-duty unit is designed for fast, accurate machining of large parts, such as engine blocks or large hydraulic manifolds.

Built with a unique 20-turret design placed in a circular pattern, the Burgmaster unit quickly and easily switches from one spindle to another. Turret index speed from one spindle to an adjacent one is only 3 seconds—and only 5 seconds from one spindle to a spindle spaced 180° away. Each turret is bidirectional and is driven by a circular rack and pinion. Milling, drilling, tapping, and boring can be accomplished with any of the 20 spindles.

In a typical application at a major auto manufacturing plant, the Burgmaster 20T-SH performs thirty-two special machining operations previously done manually. The machine is used to drill, mill, tap, deep hole drill, rough, finish-ream, and counter-bore. Total machining time per part for all operations is less than 16 minutes, a large savings over previous manual methods.

Another example of modernized machining



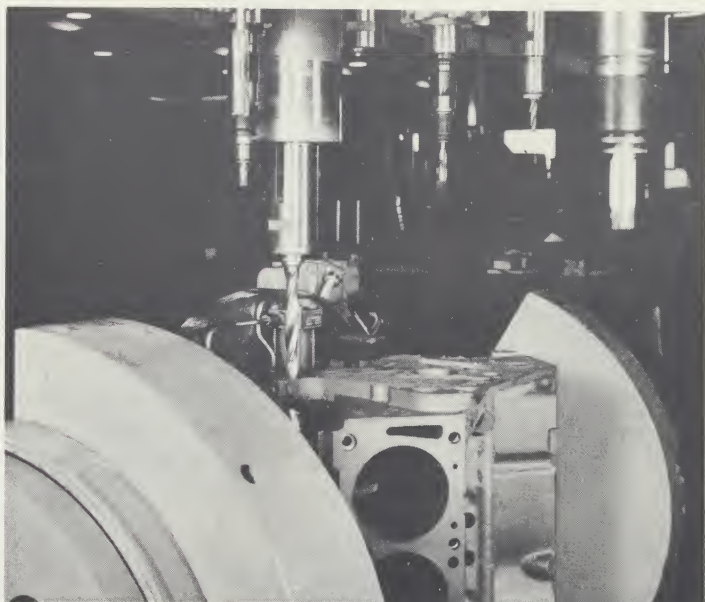
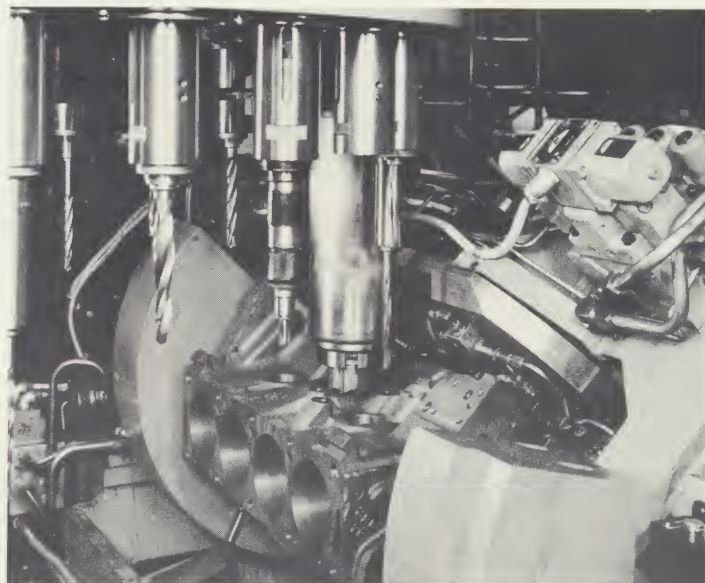
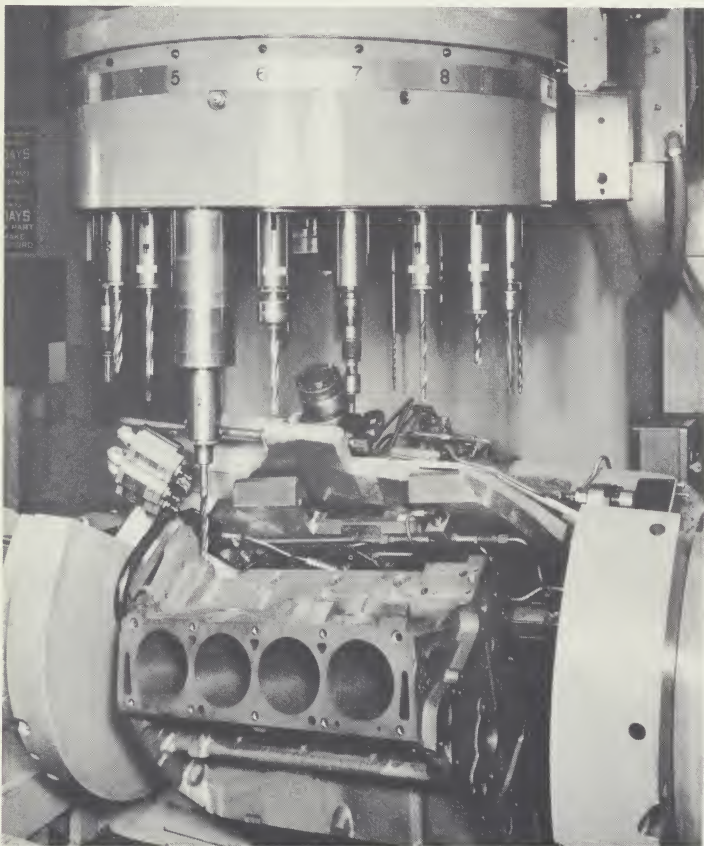
NUMERICAL CONTROL FUNCTIONS

- Operates in automatic, semi-automatic, and manual modes.
- Positions the machine elements in the X, Y, and Z axes.
- Selects spindle speed, feed rates, tool depth, clamps, dwell cycle, and length of milling cuts.
- Coolant control, reciprocating feeds and selection of 96 milling speeds are standard features.
- Options include chip blowing, index fixture control of offsets for all 20 tools, and spindle orientation.

savings

In a typical application, the Burgmaster 20T-SH performs 143 job operations on six sides of a single hydraulic manifold. The part is machined complete from raw stock in 48 minutes compared to previous machining time of 4.2 hours by conventional methods. Operations include several drilling depths for each tool and several instances of extra-deep drilling.

In another application shown below and to the right, the Burgmaster 20T-SH machines all sides of an engine block in seven motions.



For detailed information on the Burgmaster 20T-SH machining center, write to Burgmaster, Division of Houdaille Industries, 13900 S. Broadway, Los Angeles, California 90061.



BURGMAS

DIVISION OF
HOUDAILLE INDUSTRIES, INC.



Mark
Century

GENERAL  ELECTRIC

For descriptive information on General Electric numerical control systems, write for N/C DATA FILE, GEZ-3774, Distribution Services, General Electric Company, Schenectady, New York 12305.



Mark Century* 100L Numerical Contouring Control

A packaged Mark Century two-axis system designed
for automatic operation of turning machines

*Trademark of General Electric Company

GENERAL  ELECTRIC



Mark Century 100L

numerical contouring control

easily justified in any plant . . .

Mark Century packaged numerical controls are available in several models—each tailored to a special type or group of machines. The 100L control is designed particularly for use with lathes, and incorporates many capabilities previously available only in much more expensive custom-designed models. This range of capabilities enables the General Electric Mark Century 100L control to meet any lathe requirement except the most unusual turning jobs.

There are other GE packaged systems for point-to-point operation, turning, profile milling, and boring. All come in a basic design with a number of pre-engineered options which can be added inexpensively for extra versatility. The user benefits from the packaged-design concept by getting traditional Mark Century performance on machines of his choice—without paying for unnecessary custom engineering.

Furthermore, all GE packaged controls are similar in design and construction. This compatibility can reduce operating costs significantly where several Mark Century controls are in use because training expenses are less and overall operating efficiency is improved as a result of similarities in programming and maintenance.

The 100L control is offered by leading builders of turning machines. These machine tools with Mark Century 100L controls offer the user outstanding value.

GECENT postprocessor, part of the computer software support package available to Mark Century N/C owners, simplifies continuous-path programming by quickly converting control data generated by the APT computer program to input for the numerical control.

Highly reliable

The Mark Century 100L control employs the same high-quality construction standards and components found in all General Electric Mark Century controls. Furthermore, reliability of the 100L control is backed by General Electric's more than a decade of experience in building numerical controls for over 150 different U.S. and foreign machine-tool manufacturers.

The full inherent reliability of transistorized, printed circuit boards is put to use on the GE Mark Century 100L control. Input data is distributed, stored, and acted upon by solid-state circuitry. Materials, fabrication methods, and components used meet the strictest industrial standards.



Total service package

When the Mark Century 100L control is delivered to your plant, GE startup and check-out specialists are on hand to assist with installation and make certain the control operates according to specifications. And should you need fast, skilled maintenance service, General Electric N/C Service Engineers from a nationwide network of over 50 offices can provide it.

But General Electric's service package doesn't stop there. To help your personnel care for the Mark Century 100L control after installation and start-up, a two-week maintenance training school is conducted at the factory. Also included in the most complete service package in the industry today are:

- Automatic check tapes
- Unmatched product warranties
- Local stocking of replacement parts
- Complete service and installation manuals
- Printed circuit board exchange plan
- Full computer software support
- Service engineers on call 24 hours a day

for two-axis turning machines

The Mark Century 100L control is a two axis N/C system specially designed for turning and boring operations. Features such as 3-digit spindle and tool codes, tool offsets, full range of thread-cutting provisions, and circular interpolation for manual programming give it the capability for essentially all horizontal or vertical lathe applications.

Maximum flexibility for turning

The Mark Century 100L control provides for changing tools automatically to reduce delays on multiple tool programs. Tool changing is quick and simple—initiated each time a different "t" code is ready. Any pair of tool offsets may be used with any turret.

As an optional feature, digital synchronization between spindle and feed drive permits thread-cutting of almost any type of design.

The Mark Century 100L N/C accepts incremental commands, has buffer storage, and is a linear/circular interpolation system. Straight cuts and slopes up to 9.9999 inches of departure, or arcs up to 9.9999 inch radius may be programmed in one block. Short dimension preparatory commands are provided for departures or arc radii less than one inch. This reduces cycle execution time. Electrical resolution is ± 0.0001 inch with absolute control positioning accuracy of ± 0.0004 inch.

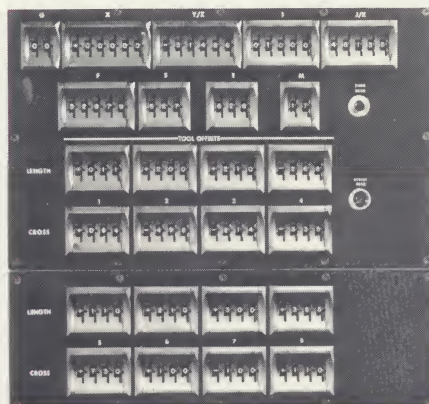
All these features make the Mark Century 100L lathe control best suited for the widest range of turning applications—at a cost greatly below conventional custom-designed systems

Simplified programming

To make programming and maintenance easier, the Mark Century 100L control has a binary-coded decimal format using standard EIA, 8-channel punched tape that is read by a photo-electric tape reader at a speed of 300 characters per second. In addition, the control may be operated on manual mode or by jog push buttons.

To save time, the Mark Century 100L control operates at high traverse speeds without the need to program acceleration and deceleration steps between traverse and feed rates. Up to 275-ipm traverse and 40-ipm feed rates may be used.

Insertion of complete operation commands by manual data input panel is a valuable aid in setup, initial program checkout, maintenance, and prototype work.



Easy to operate

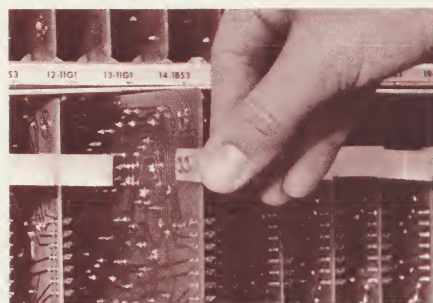
The console on the Mark Century 100L control is designed for maximum operator handling convenience. Miniaturized push buttons and other operator devices are functionally arranged on a sloping panel across the top front of the unit.

A check tape and condition-indicator boards provide fast, thorough check-out of the control-reading and data-storage circuits.

The logic-circuit portion of the control system is functionally arranged in modularly constructed panels of plug-in printed circuit boards. To make board changing easy and fool-proof, both the boards and rack slots are identified by function code.

A modern NEMA 1, air-conditioned, floor-mounted enclosure houses all control components. Both plug-in control connections and swing-open gasketed doors—front, back, and top—provide easy access to all parts of the unit.

Measuring 52-inches wide, 42-inches deep and 74-inches high, the Mark Century 100L control has a heavy-gauge steel cabinet with logic wire connections that are wrapped instead of soldered for high reliability and performance.



Mark Century 100L

numerical contouring control



Standard Features

High-speed Reader — 300-characters per second with 4 $\frac{1}{8}$ -inch reels.

Full Manual Data Input — Thumb-wheel switches can insert full operation commands for manual operation in setup and prototype work.

Incremental Feed Switch—Permits manual movement of selected increments from 0.0001 to 1.0 inch.

Jogging Mode—Provides rapid manual movements to aid setup and maintenance.

Sequence Number Readout — Displays program block in process, enabling speedy search of program sequences.

Programmed Dwell — Delays slide movement up to 99.999 seconds for tool changing and other purposes.

Spindle Speed Selection—Up to 1000 different spindle speed codes are available.

Tool Selection—Any pair of tool offsets may be programmed with any turret position by 3-digit "t" codes.

Tool Offsets—Four pairs of thumb-wheel switches provide up to 0.0999

inch offsets on the X and Y/Z axes.

Miscellaneous Functions—Up to 100 commands may be used to control functions such as spindle direction and gear changing.

Maximum Feed Rate — Feed rate numbers as large as five digits to a maximum of 500.00 may be programmed.

Feedrate Override—A selector switch allows operator to vary programmed feedrate from 0–120% as needed for setup operations.

Zero-positioning—Push buttons move all motions to zero position, synchronizing machine to start contouring program.

Block Delete—Tape code and hand switch permit control to skip blocks of data which don't apply to present operation.

Feedhold Push Button — Can stop motions anytime without losing synchronization.

Overtemperature Protection — Warns operator of heated conditions in the control cabinet.

Sprocket-hole Verification—Prevents misreading due to improper align-

ment and timing of the tape in reader.

Parity Override—Permits tape identification on the leader by ignoring everything prior to an end-of-block code.

Servo Drives — Either SCR electric motor, or electro-hydraulic systems may be provided.

Tape Parity Check—Stops all motion and lights an error light indicating a tape error.

Out-of-synchronism Protection — Automatic error limit prevents difference between commanded and actual positions from exceeding a predetermined amount.

Machine Mode Selector — Permits control to be operated in three modes:

Automatic — All machine commands come from programmed tape.

Semi-automatic — Machine operates from commands entered by operator on manual-data-input panel.

Manual—Operator may direct motion by jog buttons.

Optional Features

Threadcutting — For longitudinal, face, and tapered threads—variable and constant leads—up to 9.9999 inches per revolution.

Extra Tool Offsets—Up to four additional pairs of tool offsets may be

added to the standard four pairs as needed to control multi-tool turret lathes.

Emergency Tool Retract — Retract button instantaneously withdraws tool in direction assigned by turning mode.

High-speed Reader—Permits reading of up to 500 characters per second, has 8-inch reels.

Full-floating Zero — Differential resolvers allow programmer to establish zero reference point at any desired location.

There is a Mark Century numerical control system to fit your needs, whatever your performance requirements. For more information contact a General Electric Sales Office or your machine-tool builder.

Specialty Control Department, Waynesboro, Virginia

GENERAL  ELECTRIC

Ex-Cell-O Numera-Trol Model 952 Profiling Machine

with General Electric Mark Century* 3-axis contouring control
assures accurate airfoil on compressor or turbine blades

*Trademark of the General Electric Company

FEATURES

- Airfoils machined complete at one setting
- Part design not limited by manufacturing or machining capabilities
- Exact part duplication possible with numerical control
- Lead and setup time are reduced, precision enhanced
- Storage space for cradle-type fixtures eliminated
- Mills airfoils up to 60" long by 11" wide

DESCRIPTION

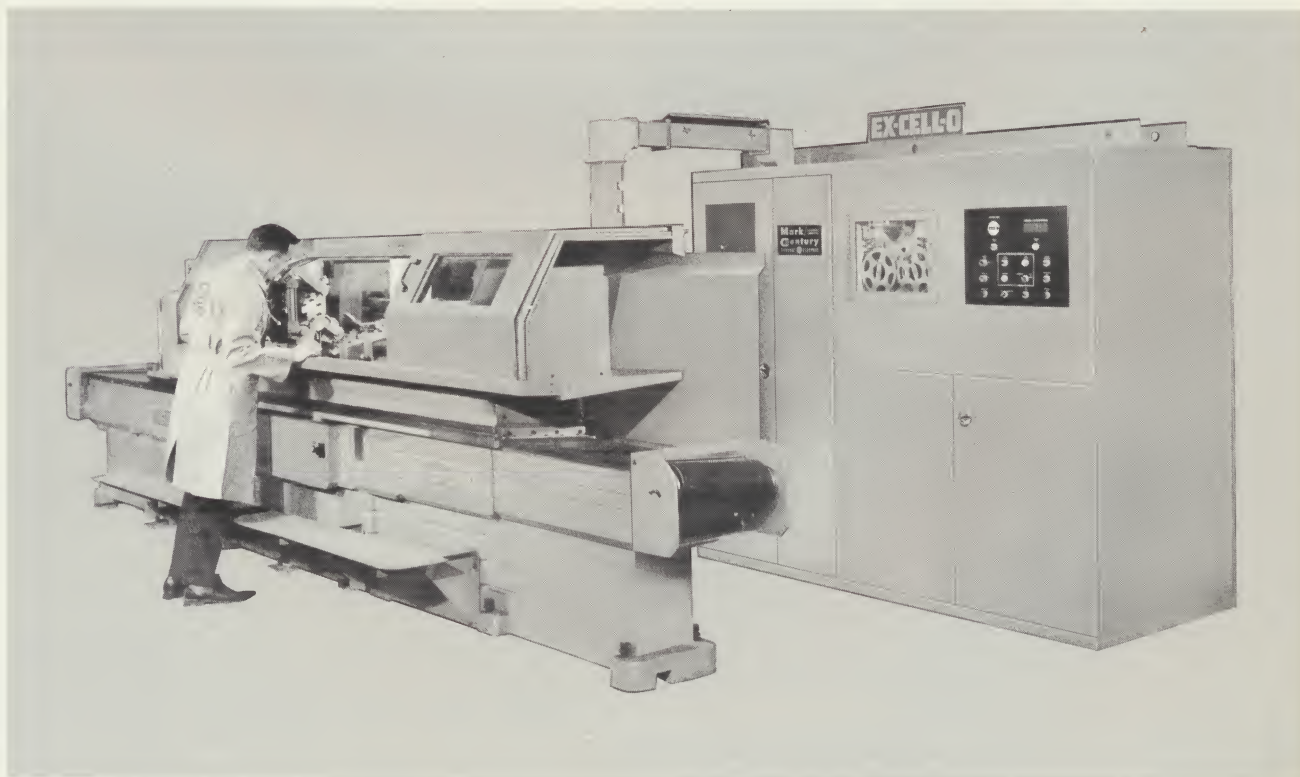
The Ex-Cell-O Numera-Trol Model 952 Profiling Machine with GE Mark Century three-axis contouring control produces airfoil contours of steam-turbine buckets and jet-engine blades, certain types of drum cams, and other parts having intricate finished forms.

Workpieces are mounted on the worktable between centers or chucked at one end, and the milling cutter, carried by an Ex-Cell-O precision spindle, is mounted on the cross slide.

During a typical milling operation, the control system radially positions the work spindle which is then clamped. The cross slide feeds in and out while the table feeds for a distance equal to the length of the cut, under continuous path control.

At the end of each stroke, the Mark Century control indexes the work spindle a programmed increment, and a cut is made on the return stroke. This cycle is repeated until the full 360 degrees is covered. The part is supported by back-up rollers along its full length. Back rests and work spindle are automatically clamped and unclamped for each cut. Maximum airfoil capacity is 60" long by 11" wide.

Another example of modernized machining



NUMERICAL CONTROL FUNCTIONS

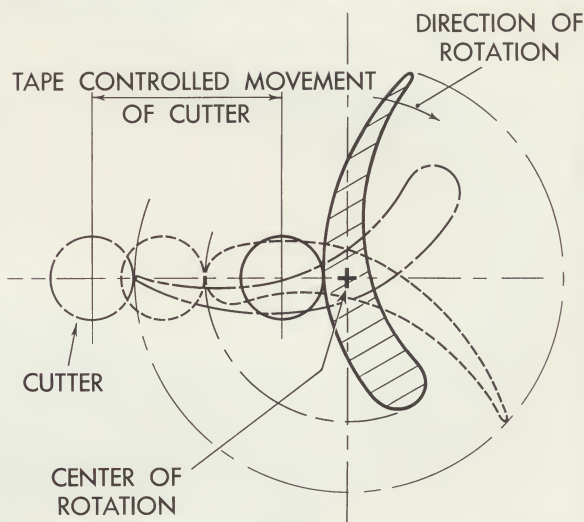
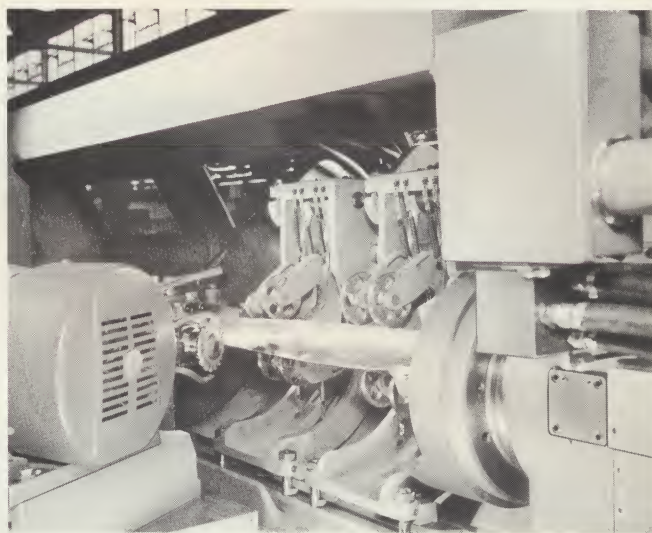
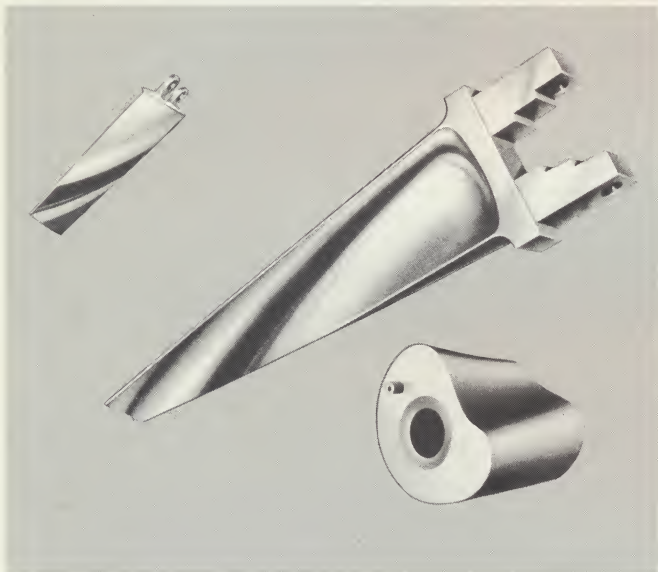
- Three full-contouring axes
- Fully automatic control of milling cutter plus auxiliary functions for complete part programming
- Feed rate override capability
- Tape parity and simplified circuit checks
- Arc programming up to 90° with one block of input data
- Out-of-synchronization protection

- Stop-cycle function stops machine feeds without losing synchronization
- Rotary resolver feedback has 0.0001" resolution for linear motions and 0.01° for rotary motion
- Sequence number readout
- Programmable dwells
- Spindle start and stop, clamp and unclamp programmable from tape

Savings

Prior to using the numerically controlled Model 952, milling operations on a 27" bucket totalled 3 hours, 45 minutes and required 4 operations with handling between each operation. In addition, tooling took 9 to 12 weeks.

With the Numera-Trol Model 952 and Mark Century contouring control, milling takes just 1 hour, 20 minutes and no tooling or extra handling is required. What's more, polishing time is cut 25%.



At end of each stroke, Mark Century control indexes work spindle and a cut is made on the return stroke. This cycle repeats until the full 360° is machined.

For more information on the Numera-Trol Model 952 profiling machine, write Ex-Cell-O Corporation, Box 386, Detroit, Michigan 48232.



EX-CELL-O CORPORATION
MACHINE TOOL DIVISION
BOX 386, DETROIT, MICHIGAN 48232

Mark
Century

GENERAL ELECTRIC

For descriptive information on GE numerical control systems, write for N/C Data File, GEZ-3774, Distribution Services, General Electric Co., Schenectady, N.Y. 12305